# Nature

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*"To the solid ground*
*Of Nature trusts the mind which builds for aye."*—WORDSWORTH



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Simon Newcomb

# NATURE

A WEEKLY ILLUSTRATED JOURNAL OF SCIENCE.

"*To the solid ground
Of Nature trusts the mind which builds for aye.*"—WORDSWORTH.

THURSDAY, MAY 4, 1899.


## *SCIENTIFIC WORTHIES.*

### XXXII.—SIMON NEWCOMB.

NEWCOMB must be considered, without contradiction, as one of the most celebrated astronomers of our time, both on account of the immensity of his work and the unity of view which marks the choice of the subjects treated by him.

All is linked together in our solar system: the study of the motion of each one of the celestial bodies forming part of it is based upon the knowledge of a great number of numerical data, and there exists no fundamental element whose influence is not repercussed on the entire theory of these bodies. To endeavour to build up the theory of our whole planetary world on an absolutely homogeneous basis of constants was an almost superhuman task.

The evaluation of each one of these data demands, indeed, that one should attentively go over most of the previous researches, and continue them by more thorough methods. All Newcomb's work, followed up with rare perseverance, has constantly tended to this ideal end: first to arrive at a more exact knowledge of the magnitudes serving as points of reference, and then to establish the theory, not only of all the planets, but also of their satellites on a system of constants as precise as modern observations permit. Wishing to realise in a complete manner this vast programme, Newcomb has recognised that the published observations do not always furnish the necessary information for obtaining with exactness all the looked-for elements. Abandoning, therefore, the domain of pure speculation, he has given himself up to researches which proclaim him possessed of a talent of observation of the highest order. By personal studies he has succeeded in filling many of the gaps which seriously impeded the progress of theory. Thus, in order to determine the masses of Neptune and Uranus and the elements of their satellites, he made a series of observations of great value, on which are partially founded the ephemerides inserted in all nautical almanacs.

I shall simply mention here in a few words some of the preparatory work preceding the construction of the magnificent edifice of which I have indicated the plan, on the happy completion of which the scientific world is to be congratulated. Throughout its execution one recognises the sign of a master-mind whose conclusions assume a definite character and remain acquired to science.

The solar parallax is one of the most essential data which intervene in all researches concerning the planetary system. Newcomb undertook to fix its value by the discussion of all the transits of Venus observed previously to 1882. In a very detailed memoir, he calls astronomers' attention to the danger to which they are exposed by giving an exaggerated confidence to certain modern methods. The systematic exclusion of the ancient observations cannot sufficiently be justified by discordances which exist between their results and those obtained more recently. By a minute and impartial discussion of all existing documents, Newcomb arrived at a value almost identical with the one adopted in 1896 by the International Conference of Paris.

Again, in order to obtain by an altogether independent means the value of this same constant, Newcomb undertook a determination of the velocity of light, based on the ingenious method suggested by Léon Foucault. These researches of a physical nature opened the way to an important advance in our knowledge of the heavens. In fact, we had all reason to hope that the value obtained for the velocity of light, combined with the constant of aberration, would allow us to determine the solar parallax more accurately than by the usual astronomical methods. Newcomb holds that multiplicity of methods is an essential condition of success; this motive led him to choose Foucault's method, which he applied with rare sagacity. The agreement between the different results obtained in this way by Cornu, Michelson and Newcomb is an admirable one, and testifies to the knowledge and skill of the experimenters. With the help of the values found for the velocity of light, it would have been possible to deduce the parallax, if recent observations had not revealed the uncertainty which still hovers over the real value of the aberration constants.

I cannot close the list of these preparatory studies without referring to a subject which interests the highest problems of astronomy of precision.

The observations of the planets and of the moon depend on the coordinates of the fundamental stars, of which unfortunately we possess as yet no catalogue absolutely free from systematic errors. One of Newcomb's constant preoccupations was to try to constitute a uniform system of points of reference, at least in right ascension, this coordinate having we ghty importance in the case of observations of moving bodies. The catalogues drawn up by him, and by Auwers, for the fundamental and bright stars of the ecliptic, have shared in equal measure up to a very recent date the favour of astronomers. But the use, in the same scientific research, of elements derived from different sources, presents inconveniences acknowledged for a long time. A reform in this direction had become very desirable. This circumstance has again afforded Newcomb the opportunity of manifesting the inexhaustible resources of his activity and talent. An international conference, held in Paris in 1896, under the auspices of the Bureau des Longitudes, had as its object to elaborate a common system of constants and fundamental stars to be employed in the astronomical ephemerides. Newcomb took one of the most important parts in the discussions and resolutions of this conference. At its suggestion he has undertaken, not only the research of the definitive values to adopt for the lunar-solar precession and the planetary precession, but also the construction of a new catalogue of fundamental stars in accordance with the system of elements chosen by the Paris meeting of astronomers. Newcomb has consecrated these two later years to the accomplishing of this arduous task. The catalogue of fundamental stars, which he has just finished, will come into use in the beginning of 1901, and will realise in the work of astronomers that unity and simplification so long desired.

I now come to the labours which have absorbed the greatest part of Newcomb's scientific activity: they refer to the domain of celestial mechanics.

At the time when the great work of Le Verrier had only reached the tables of Jupiter, Newcomb published an excellent theory of the two planets furthest from us, Uranus and Neptune. These tables, from the moment of their appearance, have been used by astronomers of every country.

Among the greatest triumphs of Newcomb's career must be counted his many and fruitful researches on the motion of the moon The theory of the moon bristles with difficulties. No one has yet succeeded in establishing a complete harmony between theory and observation. In his lunar tables, Hansen, in order to obtain this accordance for a limited interval of time, was obliged to attribute to an inequality arising from the action of Venus an empirical coefficient of an excessive amount, and to adopt besides an acceleration of the secular movement twice as great as that which results from the law of universal gravitation according to the calculations of two illustrious geometricians, Adams and Delaunay. Should we, as a great number of *savants* think, attribute to Hansen's number, so far from the theoretical value, an indisputable reality, and try to discover the physical causes of the anomaly; or should we see the origin of the disagreement in an erroneous interpretation of historical documents? Newcomb did not recoil before the difficulties which the solution of this problem entailed. He discussed all the occultations observed since the invention of the telescope up to a recent time; he himself examined forgotten observations, buried for one hundred and fifty years in the registers of the Paris Observatory. These neglected documents have thrown a vivid light on the question. In thus utilising an abundant harvest of new information, and correcting Hansen's theory by the exclusion of every empirical coefficient, Newcomb arrived at results of fundamental importance. He proved, agreeing in this with Tisserand's researches, that the eclipses of the Almagest, and those of the Arabs, as well as the ancient occultations, agree very well with the theoretical value of the secular acceleration; and further, as a corollary, that the most ancient solar eclipses, the representation of which would seem to demand an increase of the secular acceleration, can without scruple be left out of consideration, either because the reality of the phenomenon remains doubtful, or because there exists too great an uncertainty in the hour and place of observation.

One might without inconvenience, therefore, adopt the theoretical acceleration of 6″, correcting the mean motion and the longitude of the epoch. But whatever value is chosen, and this was not anticipated, one must, after having suppressed Hansen's erroneous inequality, resign oneself to introduce another notable empiric term of a period of about two hundred and seventy years, and of an unexplained origin; one simply notes that this amplitude is nearly that of an inequality due to Venus, the existence of which is not doubtful.

Besides this empiric inequality, Newcomb has discovered another, less pronounced, with a coefficient superior to 1″, with an amplitude of about twenty-seven days, and appearing to be associated with a long period perturbation of the excentricity and perigee. These delicate deductions have since been confirmed by the theoretical researches of Messrs. Neison and Hill, which show that the terms in question are due to the action of Jupiter. By all these investigations, Newcomb has elucidated, in a masterly way, the actual state of the theory of the motion of our satellite.

The two theories of the moon which must be considered the best are those of the two celebrated geometricians, Delaunay and Hansen; they are founded on totally different methods. By the help of a long, minute and tedious transformation, because it is a question of formulæ occupying several quarto volumes, Newcomb has rendered their expressions immediately comparable, bringing them moreover to a system of precise and uniform constants.

Further, by this comparison, he has shown that, in spite of the difference of method, the two theories lead to identical results for solar perturbations, which form the essential part of them and are indeed the only ones which were calculated by Delaunay.

I must now pass very briefly to some of Newcomb's other memoirs. One of his most original researches is relative to Hyperion, Saturn's seventh satellite, discovered almost simultaneously by Bond and Lassell.

The movement observed was in disaccord with the prediction of theory. In fact the major axis of Hyperion's orbit, instead of moving, directly, round Saturn in a century, accomplished a revolution in the opposite direction in the short period of eighteen years.

Newcomb has proved that this rapid retrograde revolution is caused by the perturbing action of the next satellite Titan.

In the various volumes of "The Astronomical Papers for the use of the American Nautical Almanac," Newcomb has published a great number of memoirs. One can follow step by step the immense progress achieved in the execution of the vast project which he had taken upon himself to accomplish.

It is difficult to convey an idea of the considerable efforts, the sagacity which must be displayed, the numerous investigations which must be accomplished, in order to make known to a sufficient degree of approximation the motion during a century of a body of our planetary system. Only those scientific men who have given themselves up to analogous studies can appreciate the enormous expenditure of physical and intellectual energy which must have been necessary to Newcomb in order to bring to a happy end the researches on the four planets nearest the sun. Newcomb has based his work on more than 60,000 observations, which he has compared with Le Verrier's tables; the perturbations have been calculated with great precision. While Newcomb has thus founded theories of these planets on a more precise basis, his celebrated collaborator, Mr. Hill, has obtained the same results for the two planets Jupiter and Saturn.

Henceforth, science will profit by the fruits of this immense labour, consisting of the tables of the planets Mercury, Venus, Mars and the Earth. In a special volume there are to be found various researches on the fundamental constants of astronomy.

We have only been able to give a short sketch of Newcomb's achievements; he is gifted with a prodigious power of work, which is testified by the extraordinarily long list of his researches.

The reception which has been accorded to them by all competent men points to their author as one of the most illustrious representatives of celestial mechanics.

This activity has embraced the most diverse branches of astronomy. Not only has he given a great scope to the intellectual movement of his country, but he has also contributed in a very successful manner to elevate the level of the civilisation of our age, enriching the domain of science with beautiful and durable conquests.

LOEWY.

## *THE TEMPERATURE-ENTROPY DIAGRAM.*

*The Entropy Diagram and its Applications.* By J. Boulvin, Professor at the University of Gand, Belgium. Translated by Bryan Donkin. Pp. xii + 70. (London: E. and F. N. Spon, Ltd., 1898.)

RANKINE'S "Thermodynamic Function $\phi$" (defined by $t.d\phi = dH$) is now called "Entropy $\phi$." The state of a pound of stuff which has only fluid stress and strain is completely defined when we know the values of any two of $p$, $v$, $t$, E or $\phi$ [during change of state the two must not be merely $p$ and $t$] where E is the intrinsic energy and $\phi$ is the entropy. When we say that E returns to its old value if we bring the stuff to the same state again, we state the first law of thermodynamics in its most general form. When we say that $\phi$ returns to its old value, we state the second law of thermodynamics in its most general form.

A curve connecting the values of any two of the above coordinates will, therefore, completely define the changing state of a pound of stuff. Rankine does not seem to have used the $t,\phi$ coordinates graphically, but he used them very much indeed in the algebraic form; and the idea that a $t,\phi$ diagram might be constructed was published by several mathematicians more than a quarter of a century ago. In truth, the idea was familiar to all students of Rankine, but until Mr. Macfarlane Gray began his crusade in favour of the use of the $t,\phi$ diagram in practical steam engine calculation, no other person had any idea of the changes that its use would effect.

When a pound of water-stuff alters in pressure and volume in any assigned way, at what rate does it receive or give out heat? This is the problem that we used to solve in the most laborious way; and so troublesome was it that I question if anybody, not a lecturer, ever worked out more than one example completely. The problem was never put before any but the most advanced students.

Now, thanks to Macfarlane Gray, this sort of problem is not only taken up and solved by the average student in the most elementary classes, but it is of all problems the one whose solution is most easily understood; and it is through such work that we now most easily introduce the average student to the laws of thermodynamics and the properties of steam and water. For twelve years it has been one of the commonest of class problems to take an indicator (or $p,v$) diagram, and assuming a certain wetness of the steam at the beginning of the expansion, to convert it into a $t\phi$ diagram.

Prof. Boulvin has not added to our knowledge of theory or the practical application of the $t\phi$ diagram, but in his well-known "Cours de Mécanique appliquée aux Machines," in 1893, he made the method known to continental students, and exhibited the conversion of $pv$ to $t\phi$ coordinates in a fourfold diagram; whereas in England such a conversion has always been on one diagram. Our method has possibly been such that the result is confusing to all but the man who carries it out; but this is the fault of all graphical methods of working problems. It has the merit of utilising the whole of a sheet of paper instead of one quarter of a sheet. The English method may be recommended to a student who wants an accurate answer. Prof. Boulvin's method may be recommended to a lecturer who wishes merely to *illustrate* the connection between the $p,v$ and the $t\phi$ diagrams.

The solution of the problem is really very misleading, for, invariably, the assumption is made that there is no moisture in the cylinder at the end of the exhaust. This assumption is the basis of the method used by Hirn and his numerous followers in that kind of study of the steam engine which is usually supposed to be complete. It does not seem to be understood that if there is any moisture in the cylinder at the end of the exhaust, Hirn's

elaborate analysis is utterly wrong; and yet there is every ground for believing that even when steam is somewhat superheated when leaving the boiler, even well-jacketed cylinders are never free from moisture. I am sorry to say that the Hirn analysis is often employed for cylinders with no jackets when the steam supplied is known to be quite moist. As an academic exercise, no one would object to the method of study if students were informed of its uselessness in most practical cases, but, unfortunately, this information is never given in treatises which advocate the method.

If there is no leakage past the piston, we are sure that, from the beginning of the expansion to the release, we are dealing with the volume and pressure of a quantity of stuff which does not alter in amount. This is only a portion of an indicator diagram; and, as I have already pointed out, our usual study of it is based upon an unwarrantable assumption. But what are we to say of men like Prof. Boulvin, who pile upon this Pelion, Ossas of further assumption for the sake of making pretty academic problems, and then publish the solutions of these problems as if they were of practical importance?

Of course we may, if we please, say that when steam is released to the condenser, we can imagine the whole change as occurring in the cylinder itself; only we ought to remember that we are substituting a very simple hypothetical process for a very complicated reality, which has almost nothing in common with it. We ought to remember that the very pretty, beautifully complete, cyclic $t\phi$ diagrams, which we obtain from childish assumptions, may get to be looked upon by students, and even by ourselves, as having a real meaning.

The engineering teacher is much too apt to fill up the time of students with an elaborate and systematic course of instruction on a subject in which only a few lessons are essential, and, indeed, in which only a few lessons ought to be admissible. In some German schools we have systematic courses on graphical statics lasting whole terms or years. Courses on practical geometry are never supposed to be of use unless the student draws every imaginable kind of curve, draws every imaginable kind of intersection of surfaces. When some man who really thinks for himself has, after endless opposition and worry, convinced teachers that a certain kind of exercise is of value, his converts make his modest proposals into an elaborate academic system. There is no imaginable problem which does not become part of an elaborate course of exercise work. A student becomes wonderfully learned, but he loses the power to think things out for himself. Macfarlane Gray's method of study may be made part of a student's mental machinery in a few lessons, and in these few lessons it enables an elementary student to do easily what Hirn did with so much trouble; but, in truth, its great value lies rather in its enabling students to work out for themselves the well-known results of Rankine and Clausius. They see at a glance that liquefaction accompanies adiabatic expansion. They very quickly find the $p,v$ law of adiabatic expansion of steam of any wetness. They can calculate easily the work that would be done by a perfect steam engine using the Rankine cycle, and many other important things which the average student used to take on trust. Not only does the $t\phi$ diagram enable one to see at a glance the reasonableness of much that used to be very obscure, but it clears the ideas of men who still prefer to work algebraically.

It is quite usual now in classes for students to prepare for themselves $t\phi$ sheets on which not only are the $t\phi$ lines for a pound of water and a pound of steam laid down, but also lines of constant $p$ and constant $v$ and constant E for wet, and also for superheated steam; and with these sheets many interesting problems may be worked.

The $t\phi$ sheets for a perfect gas, with lines of constant $p$, $v$ and E, are even more valuable than such sheets for steam when one desires to convert an indicator diagram of a gas or oil engine into a $t\phi$ diagram. But, indeed, the $t\phi$ diagram is nothing like so valuable in gas engine work as in steam engine work, for rate of heat reception is quite easily obtainable from the $p,v$ curve of a perfect gas. When we also remember that all idea of time is absent from a $t\phi$ curve, it will be seen that practical gas engine people are not likely to make much use of it.

Prof. Boulvin introduces his subject by a chapter on the laws of thermodynamics. He begins with—"The study of the changes produced in bodies by heat is based upon certain *fundamental laws* as the laws of Mariotte (or Boyle) and of Gay-Lussac (or Charles)." He defines absolute temperature as what is shown by an air thermometer, the zero of which is 273° C. below the ordinary zero. If adequate explanation were given, there might be no objection to these and other statements; but I am inclined to think that the ordinary reader will find such an introduction misleading. I think that some difficulty would be cleared up if the author proved the truth of the fundamental equations for perfect gases, instead of merely assuming their truth; it would lead to a much simpler treatment of the next two chapters. Parenthetically, I would observe that he is quite mistaken in thinking that a *small* error in measuring clearance in a gas engine cylinder will lead to very wrong values of $k$ in the expansion curve, $pv^k$ constant.

It would be interesting to know what the author means when, after speaking of Regnault's value 0·48 for the specific heat of steam, he says, "and this is about the same value as it would have if treated as a permanent gas, and its density calculated from its molecular weight." I think that there is almost no point of view from which this statement must not be regarded as absurd.

On the whole, the author may be said to have given an account of the subject which it is worth while for a beginner to study, should he not be able to lay his hands on the several better accounts which have already been published in England. It is a pity that the translator did not think it worth while to alter Prof. Boulvin's illustrations, for these have compelled him to use letters which will give trouble to the English student. Rankine's letter $\phi$ is universally used in England and America for entropy; here we have S used instead. I am wrong in assuming that the use of the foreign illustrations compelled the translator to employ these letters; for I see that he follows Prof. Boulvin in using $r$ for latent heat, $\lambda$ for Regnault's total heat; and, of course, he uses A for Joule's equivalent. In a book intended for English engineers, I think that either C.G.S. units or English engineers' units ought to be used. In this translation we find the hybrid units of French engineers.

Many of the names mentioned in connection with the history of thermodynamics are quite unknown to me; I nowhere find any mention of the names of Lord Kelvin or of his brother the late Prof. James Thomson, who first demonstrated the connection between pressure, temperature and change of specific volume on change of state. Rankine's name is not mentioned either, although to the English engineer this seems like leaving out the name of Columbus in a history of the discovery of America.

In the section referring to "diagrams of $CO_2$ marking the critical point," of course the name of Dr. Andrews is not mentioned, but those of Regnault and Zeuner, Cailletet and Mathias are. Of course, A is used instead of J for Joule's equivalent throughout this book.

The translator says that Prof. Unwin has read over the proofs. I wonder whether he looked over the translator's preface, in which he states, among other curious things, that "entropy in its strict sense has no meaning if employed to represent the changes of state of a fluid flowing through a vessel, and more or less throttled in its passage." If he means that a foolish man may make mistakes in using a $t\phi$ diagram, he is right enough. But if he means that a certain quantity of stuff in a certain state has not just as definite a quantity of entropy as it has of pressure or temperature, he makes a mistake which is by no means an unusual one.

Perhaps, on the whole, it is well not to extend to the translator much of the credit which one may give to the author of the book. The author may never have heard of Rankine or the Thomsons or Andrews or Maxwell, but it is really unpardonable that in the translator's list of the works dealing with "the subject of entropy" there should be no reference to anything written by Rankine.

JOHN PERRY.

## UNSCIENTIFIC NOTES.

*Haunts and Hobbies of an Indian Official.* By Mark Thornhill, author of "Adventures of a Magistrate in the Indian Mutiny." Pp. xii + 346. (London: John Murray, 1899.)

THIS is a collection of notes on various subjects jotted down by an Indian civilian, who, during part of his Indian career, kept a diary which was, he says,

"chiefly devoted to observations on the birds, insects and animals whose acquaintance I made in my garden, or which I beheld on the bed of the river beyond."

Like many writers in the earlier half of the passing century, Mr. Thornhill uses the word animals in the restricted meaning of mammals. Occasional notes on the weather, on some of the natives of India, and on their habits, institutions and superstitions, and an account of a tour in the Deyra Dun at the base of the Himalaya, are added, and make a thoroughly readable and even an interesting book, though not one to which those desirous of information as to the "birds, insects and animals" of Northern India can be recommended to turn. The best portions of the work are those descriptive of the people of India and of the scenery; the changes of the seasons, and their effects, especially on insect-life, are also well described, but similar accounts have been given by other writers. The observations recorded were evidently made in parts of the North-western Provinces of India.

It is chiefly as a contribution to the zoology of Northern India that Mr. Thornhill's book demands notice here; and in this respect it would be difficult to find a more unscientific work. For science is essentially the accumulated experience of many men, and they who trust entirely to their own observations and neglect to make themselves acquainted with facts recorded by others, must not be surprised if the majority of their accounts are superfluous, and some of them erroneous. In the present work we have description after description of certain habits of the animal world well known to every Anglo-Indian, and useless to those unacquainted with India, because the author is unable to identify the animals observed. For instance, on p. 192 he describes in considerable detail a remarkable bird's nest. But although he must have devoted time and labour to obtaining and describing the nest, it does not appear to have occurred to him to inquire what bird built it, or whether any other observer had investigated this interesting form of bird-architecture. Yet from the description of the nest, and from the manner in which the structure was suspended from high grass, it is easy to recognise the nest of a weaver bird, and even to identify the species as probably the striated weaver bird *Ploceus manyar.* Any one who compares Mr. Thornhill's notes with those in Jerdon's "Birds of India," or better still with the elaborate account given in Hume's "Nests and Eggs of Indian Birds," must appreciate how useless the first-named are.

In the case just quoted, Mr. Thornhill, though his observations add nothing to what was well known before, does not mislead; so another instance may be taken, when his information is not only imperfect but incorrect. The following are extracts from his account (p. 118) of the animal well known in India under the name of the "musk-rat."

"This rat, fortunately, does not make its residence in the houses, and indeed it only occasionally enters them, and then as a rule by night. I do not know whether after all it is a true rat. In appearance it more resembles a very small, nearly hairless, ferret. It is of a drab colour, and has that half-transparent look noticeable in young mice and unfledged chickens. Its presence is manifested by a squeaking cry, accompanied by an intolerably sickly odour, something resembling musk. The odour is so penetrating that, according to the European popular belief, it will pass through the glass of a bottle and flavour the liquor within. The fact is correct, but not the explanation. Beer and wine are certainly occasionally flavoured by these rats running among the bottles that contain them, but the odour penetrates not through the bottle, but through the cork."

The so-called musk-rat of India is, of course, a large shrew, and resembles a ferret about as much or as little as the common English shrew does. It varies in colour, but is generally slatey-grey to bluish-grey. If it does not spend the day actually in houses, it haunts their immediate neighbourhood, merely hiding in holes. Its presence is not necessarily manifested by any odour, as Sterndale has shown. Lastly, the absurd old story that liquors in bottles become impregnated with the peculiar odour of the secretion from the lateral glands of the musk shrew, whether the scent was supposed to pass

through the bottle or through the cork (the corks, it should be remembered, were almost always covered with resin outside), was disposed of, as most of us believed for ever, by Jerdon thirty-two years ago, when he pointed out that liquors bottled in England were never impregnated. This view has been confirmed by later observers, amongst others by McMaster and Sterndale. When Indian-bottled beer or wine was tainted, the mischief was doubtless due to the use of dirty bottles or contaminated corks.

But even on subjects apart from zoology, Mr. Thornhill's information cannot always be trusted. Thus, on p. 213, he discusses the signification of the names Siwalik (or as he writes the word Shewalic) and Himalaya. Incidentally (p. 212) he states that the Siwaliks are of a different geological formation from the Himalayas, which is correct, and that they are considered to be of far greater antiquity, which is the reverse of the fact. Then he proceeds to remark that the name Siwalik is properly the designation of the entire Himalaya west of the Ganges, and as such is used invariably by the native historians; he quotes the story from one of the latter, that the term is derived from two Hindi words *sewa* and *lac* (thrice misprinted *lae*), meaning one and a quarter lakhs or 125,000, and that this denotes the number of peaks, and he states that Himalaya signifies the "Necklace of Snow." On questions of this kind Yule and Burnell's Glossary or "Hobson-Jobson" is a generally admitted authority, and a reference to it shows how incorrect Mr. Thornhill's account is. The origin of the term Siwalik is doubtful, but by the earlier native historians of India the name was not applied to the Himalayas at all, but to a tract of country much further to the southward; the story about 125,000 peaks is absurd, and the name Himalaya is derived, according to Sanscrit scholars, from *hima* snow and *alaya* an abode, and not from *hima* and *mala* a necklace.

One extract more must be given. Some of the subjects above mentioned may be regarded as matters of opinion, but the last quotation to be made betrays a want of acquaintance with elementary astronomy surprising in a man of good education. No comment is necessary except that all India is in the northern hemisphere, and that in the countries referred to in the work before us the pole star is from twenty-five to about thirty degrees above the horizon. At p. 100 there is the following paragraph; the italics are, of course, not in the original.

"The constellations are not quite the same as those we see in England: *those that in England lie far to the north are here invisible*, while we look on many that in England never rise above the southern horizon."

W. T. B.

## ALPINE GARDENING.

*Die Alpen Pflanzen in der Gartenkultur der Tiefländer. Ein Leitfaden für Gärtner und Gartenfreunde.* Von Erich Wocke. Pp. xi + 257. (Berlin: Gustav Schmidt, 1898.)

THIS work is apparently written with a view to do for German gardeners and lovers of alpine flowers what Mr. William Robinson's "Alpine Flowers for English Gardens" (published in 1870, but long since out of print) has accomplished for their British *confrères*. Indeed, the author has treated his subject on somewhat similar lines. He is head gardener at the Zürich Botanic Gardens, and enjoys the great advantage of being able to study alpine plants in their natural conditions.

Nowadays every one is more or less interested in the cultivation of alpine plants, but comparatively few know how to grow them successfully, or to make suitable miniature Alps—popularly known as "Rock Gardens"—so as to resemble natural conditions at low elevations. Time was when heaps of clinkers and boulders of bricks thrown together anyhow were proudly designated as "rockeries." People know more about these things now, and those who do not, but would like to, may peruse with advantage the treatise under notice.

Mr. Wocke has dealt with the cultivation, propagation, and most suitable treatment for Alpine plants in a thoroughly practical manner, and German gardeners at least can no longer complain of the want of a good book on this subject. The reader is made acquainted with the conditions under which the various plants thrive naturally, so that he may know precisely how to treat a plant coming from a certain region or elevation. Plants that love the glare of the sun, or the shadow of a rock, or the moist, mossy bank of the mountain torrent, obviously require somewhat different cultural treatment; and the most successful gardener is he who endeavours to imitate nature as closely as possible.

The construction of the rockery is a most important matter, and the author rightly deals with it at some length. As a rule, horizontal fissures for the roots of plants should be avoided, being contrary to the natural downward direction taken by these organs. The reader may obtain a good idea of what a rockery should be like from the one in the Royal Gardens, Kew, although here, curiously enough, the natural state of things has been cleverly turned upside down, without however, producing unpleasant effects. Thus on the summit of the rocks—or miniature Alps—the tallest plants are placed, while at the base the dwarf and stunted forms luxuriate. As Mr. Wocke points out, plants have a tendency to become dwarfer and more stunted in growth the higher they ascend the mountain side.

A valuable list of the best Alpine and sub-Alpine plants is given, with indications as to their native habitats, and the conditions most suitable for them under cultivation. In addition, special lists of plants adapted for particular situations are given, so that the reader may see at a glance which kinds will thrive in, say, moist or dry, warm or cool, sunny or shady positions.

The last chapter in the book is devoted to rectifying the nomenclature of certain more or less well-known plants, but that is a matter which concerns the botanist more than the gardener.

On the whole, Mr. Wocke's book, which is illustrated by twenty-two explanatory woodcuts and four photographs of rock gardens (at Newton Abbot, by the way), is a welcome addition to the literature on Alpine gardening. With one or two trifling printer's errors in the botanical names, the work bears traces of having been carefully edited.

JOHN WEATHERS.

## OUR BOOK SHELF.

*Commercial Cuba. A Book for Business Men.* By William J. Clark. With an Introduction by E. Sherman Gould. Illustrated. Pp. xviii + 514. (London: Chapman and Hall, Ltd., 1899.)

A THOROUGHLY practical book written from the standpoint of the American trader, "Commercial Cuba" lays no claim to either literary or scientific merits. From its own point of view it would be difficult to find anything more exactly adapted to the needs of the moment. From personal experience in Cuba, Mr. Clark is able to advise his countrymen as to the necessity for adapting their ways of living and of dealing to the peculiarities of a tropical West Indian climate and a Spanish-American population of conservative habits.

In speaking of the population, the author points out that there is no danger of Cuba becoming a second Haiti, as statistics show a tendency for the negro element to increase very slowly, if not actually to die out. Practical hints as to the preservation of health in the tropics occupy one chapter, in which the hygienic virtues of coco-nut milk are strongly insisted on. Every aspect of the economic life of Cuba is touched upon in turn, and lists are given of the more important products, with hints as to those which deserve more attention than they have yet received. A detailed account of each province, with a condensed gazetteer giving information as to every town and village, conclude the work.

The report, taken as a whole, amply confirms the general belief as to the extraordinary riches of Cuba, which has continued to flourish under difficulties imposed by population and government which no less favoured land could have endured. When the oppressive laws have been repealed, the way to the waiting markets of the United States thrown open, and a flood of American capital and American enterprise directed to its ports, Cuba promises to become all that its discoverers dared to dream. Hitherto the wealth of the island has lain in the plantation products, and mainly in two crops—tobacco and sugar; but the mineral resources appear to be enormous, and are practically untouched There exists no adequate survey of the island, either topographical or geological, and the knowledge of the native flora and fauna is still very incomplete.

Mr. Clark, in discussing the labour problem, hazards the opinion that the future working population of Cuba will be largely composed of Italian immigrants, to whom the climate, prevailing religion, and mode of life in the island will prove particularly congenial, while the language will present little difficulty. All these conditions will militate against the immigration of negroes from the Southern States, while the coloured people of the overcrowded islands of the British West Indies are considered by the author to be too poor in physique to be desirable in Cuba.

*The Free Expansion of Gases: Memoirs by Gay-Lussac, Joule, and Joule and Thomson.* Translated and edited by J. S. Ames, Ph.D., Professor of Physics in Johns Hopkins University. Pp. 106. (New York and London: Harper and Brothers, 1898.)

THIS forms the first of a series of handy small volumes containing reprints and translations of classical papers, relating to various branches of physics, which are to be issued under the title of "Harper's Scientific Memoirs." Messrs. Harper are to be congratulated on their enterprise in launching a venture which should at least prove of great service to students, especially to students of the comparatively advanced type. They are also to be congratulated on having secured so well qualified a general editor as Prof. Ames, who is personally responsible for the contents of this first volume. That such a series should be issued at all is a remarkable evidence of the development of physical study and research in America, for it presupposes a considerable public to whom such papers are matters of sufficient interest to induce a purchase. Each paper is accompanied by a few lines of biography, and is printed in a practically complete form, with the omission only of tabular or illustrative matter which could be spared without serious loss. A few notes, giving corrections or explanations, are added, and the volume is completed by a list of books and articles of reference. In a short preface Prof. Ames draws attention to Gay-Lussac's experiments—the account of which forms the first paper in the volume—as affording a justification of Robert Mayer's assumption that the heat developed in compressing a gas is the equivalent of the work spent, the assumption, namely, on which Mayer's estimate of the mechanical equivalent of heat was founded. But it does not appear that Gay-Lussac's work, even if Mayer was acquainted with it, supplied the *lacuna* in his reasoning, or in any way detracted from the credit due to Joule for his later settlement of the matter.

The bibliography might with advantage have included a reference to the remarkable application, which in recent years has been made by Linde, of the slight cooling effect which a gas suffers in free expansion. The small cooling effect which was discovered by Thomson and Joule, the investigation of which is described in the papers reprinted here, has sufficed in Linde's hands to enable temperatures to be reached which are only a little short of the absolute zero. Incidentally, the work of Linde and Dewar has shown that the effect in hydrogen is a cooling effect, as it is in other gases, and it is to this that the liquefaction of hydrogen by Dewar is due.

J. A. E.

*The New Science and Art of Arithmetic for the Use of Schools.* By A Sonnenschein and H. A. Nesbitt, M.A. Pp. x + 501. (London: Swan Sonnenschein and Co., Ltd., 1899.)

*A School Arithmetic.* By R. F. Macdonald. Pp. viii + 264. (London: Macmillan and Co., Ltd., 1899.)

MESSRS. Sonnenschein and Nesbitt's volume is a modification of one which appeared in 1870, and has for some years occupied a foremost place among school arithmetics. A number of text-books, in which the principles as well as the practice of arithmetic are treated, are now available; but the changes made by Messrs. Sonnenschein and Nesbitt should enable their work to hold its own among them. Several chapters have been remodelled in order to render the demonstrations easier; a new chapter on the properties of fractions has been introduced; least common multiple is now connected with the Euclid, Book V., and various other additions and alterations have been made to bring the volume up to date in the methods of work described.

A knowledge of the theory of arithmetical operations is essential to the student of mathematics; but ability to accurately work examples is more valuable in ordinary life than a comprehension of the principles involved in the processes employed. The only way to acquire facility in solving problems, or quickness and accuracy in arithmetic, is by steady practice; and abundant material for exercise with these objects in view is provided in Mr. Macdonald's volume. Sufficient information as to methods of working is given to enable the pupils to understand how to apply the various rules, but no attempt has been made to explain the reasons of the processes described, the purpose of the author being to establish and extend the knowledge of pupils who have already had a training in the principles of arithmetic. The volume practically consists of exercises, most of which are in problem form, and many are of the kind met with in everyday life. For students in Schools of Science, and pupils whose arithmetical faculties have become rusty, the book should be found especially suitable.

## LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### The Chief of the American Nautical Almanac.

PAGE 542 of the issue of NATURE for April 6 contains an announcement that Dr. T. J. J. See has been nominated as Chief of the American Nautical Almanac Office; but as this is entirely erroneous, I venture to hope you will correct it. Prof. See has been assigned to a subordinate position in the Naval Observatory, and has nothing whatever to do with the Nautical Almanac Office. WM. HARKNESS.

Nautical Almanac Office,
U.S. Naval Observatory, Washington, April 18.

[The announcement referred to by Prof. Harkness was based upon information given in *Science*, and was corrected in the following number (p. 562) upon the authority of the same journal. —ED.].

### Wehnelt Interrupter.

IN a previous communication to this journal (p. 438), I pointed out various methods of controlling the Wehnelt interrupter with a view to preventing the destruction of Crookes' tubes. Since then I have made a series of observations which confirm what was previously stated. The principle upon which the experiments were conducted was to keep all the factors constant with one exception, the amperage, voltage, results upon the fluorescent screen and photographic plate being carefully noted and registered by means of an X-ray meter. In one set of experiments the voltage was varied, in another the density of the solution, in the third the size of the platinum, in the fourth the self-induction of the primary coil. By varying any of these, or by a combination specially suited for different purposes, complete control of the Wehnelt was obtained in the way of greater or less fluorescence, actinic power, and steadiness of the screen. Briefly stated, it was found that all these effects decreased as we lowered the voltage, the self-induction of the primary, the density of the electrolyte, and the size of the platinum.

Early in these investigations, great differences between the readings across the Wehnelt and those across the terminals of the primary were observed, for the most part indicating increase in the former. An extended series of observations was made by means of Lord Kelvin's electrostatic voltmeters and ampere gauge, and a relationship between all the different factors was clearly demonstrated. Different induction coils were used, in one of which the self induction could be altered by withdrawing the soft iron core. Briefly put, it may be said: (*a*) that there was a corresponding decrease in the readings across the Wehnelt as the voltage in the primary decreased; (*b*) different conditions, such as length of spark gap, or different vacuum in the Crookes' tube placed in the secondary circuit, affected the readings considerably; (*c*) the increased voltage across the Wehnelt seemed to depend upon the amount of self-induction in the primary. In this group of experiments, it was noted that, as the self-induction increased, the voltage increased, the amperage decreased, and the number of interruptions also decreased. A non-inductive resistance was made with a view of confirming the results, and it was used instead of the primary of the ordinary coil. In this there was, however, sufficient self-induction to work the Wehnelt under certain conditions. With this arrangement, not a single reading across the Wehnelt was higher than that of the voltage across the primary. J. MACINTYRE.

Glasgow, April 28.

### Polarisation Experiment.

BY the following simple arrangement a single pile of glass plates may serve at once as polariser and analyser, and be used to study or to exhibit on a screen the interference colours with mica or crystal sections. It may not be new, but I have not seen it given anywhere. A beam of light is reflected down from a pile, polarised in the plane of reflection. Passing through a double-refracting crystal, it is resolved and then reflected by a common mirror under the crystal. On passing through the pile, which polarises by refraction in a plane at right angles to the plane of first polarisation, it shows the interference colours. Using sunlight and interposing a convex lens, we may by this simple means project the interference rings of crystal sections.

Central College, Bangalore, India. J. COOK.

### Gecko Cannibalism.

A FEW days ago, on opening the stomach of a young female gecko (*Gecko monarchus*, a species which occurs fairly commonly in the compound outside our bungalow here), it was found to contain, in addition to a caterpillar and some other remains which I could not identify, a smaller gecko of the same species; this, judging from its position in the stomach, had evidently been eaten head foremost, and was quite entire.

The lengths of the two individuals were:

| | |
|---|---|
| Larger individual | Tip of snout to cloaca, 57 mm. (tail broken off). |
| Smaller ditto ... | Tip of snout to cloaca, 32 mm.<br>Tip of snout to tip of tail, 74 mm. |

Günther, in his "Reptiles of British India," alludes to geckos as being known to destroy "the younger and weaker members of their own species," and he describes the individuals of *Gecko monarchus* as "pugnacious among themselves": but the fact that an animal will prey upon another of its own species while living under completely natural conditions and with an abundant supply of its normal insect food seems worth recording. F. P. BEDFORD.

Singapore, March 23.

### "Asia, the Land of Rice."

THROUGH the medium of your pages I would ask, Can any of the numerous readers of NATURE give information as to how or from what origin the name Asia came to be applied to a large portion of the earth's surface? Did it in olden times belong more especially to that district which we now term India? Was the name Asia used by any race of people to denote the land of spices and other valuables, whose products were brought by caravan across Persia and onward by way of the Red Sea?

In the last number of the *Journal* of the Polynesian Society (vol. vii. 185) an interesting paper, by Mr. S. Percy Smith, the Surveyor General for New Zealand, is published, "Hawa-iki: the whence of the Maori," in which he shows that Polynesian traditions tell that the Maori people of New Zealand originally started on their migrations through the isles of the Pacific from a large country which they name "Atia-te-varinga."

"In Madagascar, the name for rice is *vari* or *vare*; in Sunda (Java), Macassar, Kolo, Ende, rice is *pare*; in the Bima tongue it is *fare*; in Malay it is *padi* and *pari*. It is stated that the Arabs changed the original Malay *f* into *p*, so that originally the Malay name was *fari*."—"It is sufficiently clear from the above that *vari* means rice, and the Rarotongan tradition is correct, though not now understood by the people themselves."—"It would seem from this that Atia was a country in which the rice grew, and the name Atia-te-varinga may be translated Atia-the-be-riced, or where plenty of it grew."

In the word *varinga* the suffix *nga* is significant of the plural, and so we get "Atia the rice-growing land." TAYLOR WHITE.

Wimbledon, Hawkes Bay, N.Z., February 9.

## RECENT SCIENCE IN ITALY.

A BRIEF survey of recent numbers of the *Transactions* published by the Reale Accademia dei Lincei, or by the various other Italian Royal scientific academies, will amply show that the country to which we are indebted in the past for the telescope, the mariner's compass, the voltaic cell and other equally valuable inventions, is keeping well to the fore in all advancements of modern science.

In mathematics there have appeared, during the year 1898, papers by A. Brambilla on Steiner's surfaces, and on the surfaces of Veronese, also on the principal polygons of a gibbous quartic with a double point; while G. Gallucci has dealt with tetrahedra inscribed in a gibbous

cubic. Capelli has continued his researches on the reducibility of algebraic equations. Papers dealing with kinematical considerations have been published by E. Cavalli and C. Pietracola. The theory of groups forms the subject of papers by G. Bagnera and G. Fano; while the geometry of hyper-space and non-Euclidian geometry have received contributions from R. Banal, E. Bertini, L. Berzolari, L. Bianchi—Berzolari's paper being on an extension of Meunier's and Euler's theorems to hyper-spaces.

Of papers on higher geometry, we may note those of F. Enriques on the double planes of linear order $p^{(1)} = 1$, and on surfaces which possess a sheaf of rational curves; besides other papers by F. Amodeo, E. Ciani, B. Levi, M. Pieri, P. Pizzetti, and E. Veneroni. The Wronskian determinant has been treated by E. Bortolotti and P. Vivanti. A number of papers dealing with questions chiefly of analysis have appeared by U. Amaldi, P. Burgatti, E. Bortolotti, T. Cazzaniga, S. Pincherle, U. Scarpis, C. Severini, and others. A review of Italian mathematical work would not be complete without some reference to G. Vailati's historical papers, dealing chiefly with the early theories of mechanics.

Passing to astronomy, we find that P. Tacchini has continued his observations on the sunspots, protuberances and faculæ at the Roman College during the year. Observations have been contributed by E. Millosevich on the comet Perrine, on the planet DQ, 1898 (433), and on the last intrajovial planets. Contrary to the common opinion that the astronomy of the ancients was based exclusively on the geocentric hypothesis, Schiaparelli has shown that Heraclitus Ponticus, a disciple of Plato, had already adopted the theory that the sun was the centre of the orbits of the planets, while the earth remained the centre of the universe, and of the lunar and solar rotations—a system substantially that of Tycho.

A considerable number of additions to our knowledge of terrestrial physics have appeared during the year. Seismology has been well represented by G. Agamennone, who has occupied himself with determining the velocities of propagation of the earthquakes of Aidin and of Pergamos (Asia Minor) of 1895, and the earthquakes of India, of Labuan, and of Hayti of 1897; while P. Tacchini has considered the Emilia earthquake of 1898. Volcanic phenomena have been closely observed on Vesuvius by R. V. Matteucci. The year 1898 witnessed the rare appearance of flames on the volcano, which have been attributed by Semmola to jets of incandescent gas at a high temperature, unaccompanied by combustion; while Matteucci differs in thinking that these flames are due to the imprisonment of inflammable substances. The formation of a cupola of lava on Vesuvius forms the subject of another note by Matteucci. A highly promising field of research has been opened up in a paper, by the same writer, on the physics of flowing lava, dealing with the effect of artificial refrigeration on the crystallisation of the magma. The probable presence of coronium in the gases of the Solfatara and of Vesuvius is dealt with by F. Anderlini, R. Nasini and R. Salvadori. Bassani describes the formation of a small vent in the Solfatara.

F. Morano, in his experiments on the thermal conductivity of the rocks of the Campagna, has added fresh links of evidence on that debatable point, the age of the earth; while the second bone of contention betwixt mathematicians and geologists—the glacial period—forms the subject of a note by L. De Marchi, in reply to objections of Arrhenius.

G. Folgheraiter has recently continued his investigations on the secular variations of magnetic dip as revealed by the magnetisation of ancient vases. At the observatory of Capodimonte, the variations of the magnetic elements have been closely studied by F. Contarino and V. Tedeschi, the latter concluding that at the present rate of decrease, the magnetic declination would vanish in 113 years.

F. Angeletti has devoted his attention to the rectification of the terrestrial meridian, and has found for the earth's quadrant the value 10,000,855·76477 metres. On Mount Etna and its neighbourhood an important series of meteorological and gravitational observations have been carried out by A. Riccò. E. Oddone, working in the neighbourhood of Pavia, has investigated local variations of gravity, and the distribution and circulation of underground waters. Finally, a series of observations has been carried out on the steamer *Aspromonte* on the temperature and colour of the waters of the Adriatic and Ionian seas, of which A. Riccò and G. Saija have published a general *résumé*.

Passing from the physics of the earth to physics proper, a prominent place must be given to E. Villari's investigations on the Röntgen rays, referring more especially to their action in promoting the discharge of electrified bodies. Various experiments made by screening these rays off partially by the aid of tubes, all tend to the conclusion that the rays do not themselves promote the discharge, but cause it by means of the air on which they act. The diffusion of Röntgen rays and the influence of secondary rays emitted by bodies on which they fall have been considered at some length by R. Malagoli and C. Bonacini, whose views have been criticised by Murani. A. Battelli has continued his investigations on the nature of Röntgen rays by examining the analogy between these and kathodic rays. Other properties of Röntgen rays are dealt with by G. Guglielmo, A. Ròiti, A. Sandrucci and others. Several papers have appeared from the pen of that fertile physicist A. Righi, dealing, among other points, with the kinematic interpretation of Zeeman's phenomenon, and with the absorption of light in a magnetic field. The former of these subjects is also dealt with by O. M. Corbino. The properties of caoutchouc have been investigated by O. M. Corbino and F. Canizzaro, with regard to the variations of its dielectric constants due to traction; while M. Cantone has studied the traction and the accompanying phenomena of hysteresis from a mechanical point of view, applying his results to the determination of "Poisson's ratio." The velocity of Hertzian waves forms the subject of a paper by V. Boccara and A. Gandolfi, while Murani proves, contrary to the assertion of Le Royer and Van Berchem, that a coherer is not adapted to exhibit the maximum and minimum points of stationary Hertzian waves. In thermo-electricity, we have P. Straneo's papers on the temperature of a bimetallic conductor, and on the simultaneous determination of thermal and electric conductivities of metals. In electricity proper, we may refer to Grassi's calculation of the dimensions of induction in a continuous current dynamo, and his note on the work of magnetisation in an open cycle; A. Dina's application of aluminium to transform alternating into continuous currents: F. Lori's studies on the capacity of condensers; and A. Ròiti's paper on the two discharges obtainable from one condenser. Of thermodynamical interest are G. Bruni's series of papers on certain solid solutions, and on the equilibrium of amorphous mixtures, and of systems of two and three components with a liquid phase. C. Del Lungo deals with the density of liquids and saturated vapours considered as a function of the temperature.

In chemistry, a long series of quantitative and qualitative analyses have been conducted by Oglialoro, in conjunction with O. Forte and G. Cabella, on the waters of the baths of Belliazzi in the island of Ischia.

Menozzi, experimenting on the behaviour of certain organic nitrates in contact with the earth, has shown that hippuric acid is not absorbed or decomposed by the constituents of ordinary earth, though certain salts of this acid, similarly treated, undergo transformation. A.

Piutti has discovered a new test for the presence of wood in paper, namely chlorohydrate of *o*-Br-phenetidin, which tinges the woody fibres a bright yellow, while cellulose, ordinary fibres of cotton, wool, silk and linen are unaffected. A large number of other papers on certain new organic derivatives have been published in the *Rendiconto* of the Naples Academy, partly under the authorship of Piutti, working in conjunction with Piccoli, partly as the result of work done in Piutti's laboratory; while a detailed study of the crystallography of certain other new organic compounds, illustrated by diagrams, is contributed to the *Rendiconti* del Reale Istituto Lombardo by Boerio. Papers dealing with the methylation of the indols, and the bases derived from them, have been contributed to the *Atti dei Lincei* by A. Piccinini, G. Plancher and Bettinelli.

A geographical congress was held last April, in connection with the centenary celebrations of Paolo Toscanelli and Amerigo Vespucci.

In geology, mineralogy, and palæontology, a number of papers have appeared, but these are chiefly of local interest. We may, however, mention G. Gemmellaro's description of a new genus of brachiopods from the Sicilian *Fusulina* limestone; Artini's account of a meteorite which fell in the Somali peninsula; Bassani's work on the ichthyofauna of the eocene limestones of Gassino in Piedmont; and Taramelli's exposition of Schardt's theory, according to which a large extension of the Swiss pre-Alpine rocks is to be regarded as a limb of the secondary formation which at one time covered the Alps much further to the south.

Botany is represented by Delpino's description of several new instances of myrmecophilous plants furnished with extra-nuptial glands; A. de Gaspari's contribution to the biology of ferns dealing with spore dissemination, acarophily and myrmecophily; L. Buscalioni's work on the origin of vascular elements in the growing point of monocotyledonous roots, and his joint paper with R. Pirotta on plurinucleate vascular elements in Dioscoreaceæ; and B. Longo's researches on chromatolysis in vegetable nuclei, and on the affinities between the Rosaceæ and Calycanthaceæ.

A prominent place in the zoological literature furnished by Italy must be accorded to B. Grassi's researches on the relations between mosquitos and malaria, which have formed the subject of several notes in NATURE. Suffice it here to say that these researches have led Grassi, with the co-operation of G. Bastianelli, A. Bignami, and A. Dionisi to trace the further stages of the development of the malarial parasite within the body of the gnat *Anopheles claviger*, a work which must certainly result in facilitating the prevention of this dangerous disease in Italy. A series of papers on the morphology of Diplopods have been presented by F. Silvestri. The late A. Costa commenced an investigation on the reciprocal actions of certain animal toxins, based on the fact that the sting of certain Hymenoptera (*Scolia*) has the remarkable property of allaying the irritation due to a scorpion's sting. P. Pavesi chronicles the capture of a fish (*Coregonus Schinzii Helveticus*) near the mouth of the Ticino, probably carried down from Lago Maggiore. L. Maggi has made an extended study of the comparative anatomy of the skull, tracing the homology and homotopy of certain bones from the ichthyosaurus up to man.

Among physiological and histological papers, interest attaches to Albini's considerations on the nutritive value of whole-meal bread, which seem to demonstrate that this bread is inferior in nutritive matter to ordinary bread, besides having the disadvantage of containing an excessive quantity of indigestible matter formed of the harder parts of the pericarp of the grains. A. Montuori has investigated the formation of hæmobilin. Golgi has noted two remarkable peculiarities of the nerve-cell. Monti deals with the preservation of museum specimens, and with the pathology of nerve-fibres in anæmia, in embolism, in congestion, in hydræmia, in malaria, in poisoning, and in inflammation. The conversion of starch into sugar during digestion in the stomach is dealt with at some length by E. Oehl. Marenghi has studied the regeneration of nervous fibres in cut nerves; M. Jatta, the genesis of fibrin in pleural inflammation; and D. Baldi has applied the Baubigny process to discover the presence of bromine in thyroids.

Italian science has lost the following workers during the year 1898: Pacifico Barilari, engineer, for many years president of the Council of Public Works in Rome; Giuseppe Gibelli, professor of botany in the Royal University of Turin; A. Costa, the author of numerous papers on entomology dealing with Amphipoda, Hymenoptera, and especially with Italian saw-flies; Teodoro Carnel, botanist, of Florence; and Dr. Eugenio Bettoni, director of the Royal Piscicultural Station in Brescia.

A condensed review, such as the present, would not be complete without some reference to the long array of papers—many of them of the greatest interest to specialists—which want of space prevents us from enumerating individually, but which are none the less worthy of consideration. G. H. BRYAN.

## *HIGHER EDUCATION IN PARIS.*[1]

THE report of the Senate of the University of Paris, drawn up by Prof. Moissan, and presented to the Minister of Public Instruction in December last, gives abundant evidence of the excellent provision for higher education in Paris. It is gratifying to observe the importance attached, by State authorities in France, to the opinions held by eminent men of science on the subject of education. The record of a splendid year's work which is here brought together is proof enough, were any needed, that nothing but good can result when men distinguished in science exert their influence on Councils responsible for the administration of education.

On July 10, 1896, the new University of Paris was endowed by law with a large measure of autonomy. After the period of transition, which naturally followed the inauguration of the new University, the results of self-government have proved completely satisfactory, as the work accomplished during the school-year 1897-8 amply demonstrates. Since 1896 new chairs have been established, new courses of instruction have been formulated, new laboratories have been furnished, and the provisions for practical work have been extended in several directions. The Senate has considered many questions directly affecting their relations with the students, and has endeavoured to interest the general public in the work and development of the University. It is recognised that the University should be a national institution, and that substantial progress can only be assured by an association of effort on the part of the whole body of professors and the public.

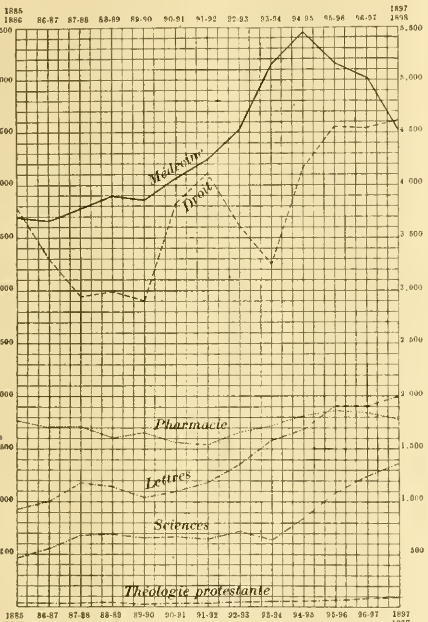
*Number of Students, &c.*—The following table shows the number of students in the various faculties for two years, that especially dealt with in the present report and the year immediately preceding:—

| | 1897-8. | 1896-7. |
|---|---|---|
| Faculty of Protestant Theology | 95 | 77 |
| Faculty of Law | 4607 | 4549 |
| Faculty of Medicine | 4495 | 5015 |
| Faculty of Science | 1370 | 1243 |
| Faculty of Letters | 1989 | 1904 |
| Higher School of Pharmacy | 1790 | 1845 |
| | 14,346 | 14,633 |

[1] Rapport du Conseil de l'Université de Paris. (Année Scolaire 1897-1898.)

The decrease in the number of students studying medicine is more apparent than real, the method of classifying and certain natural fluctuations being sufficient to explain it. The increase in the numbers taking law, science and literature has been steadily maintained for some years, though, as the accompanying curves show, there have been temporary unimportant diminutions.

The number of foreign students at the University during 1897–8 was 1258, of whom 110, representing eighteen nationalities, were studying science. There were 250 women students, of whom 187 were foreigners. The numbers of bachelor's diplomas awarded in the faculty of Science for the two years referred to above




Number of students in the various Faculties of the Paris University since 1885.

were 947 and 795 respectively. These included several branches, as follows:—

| | | 1897–8. | 1896–7. |
|---|---|---|---|
| Faculty of Science. | Classical (Literature—Mathematics) ... | 585 | 444 |
| | Modern (Literature—Sciences) ... ... | 197 | 203 |
| | Modern (Literature—Mathematics) ... | 165 | 148 |
| | | 947 | 795 |

It is interesting to note that fifty scholarships are offered by the State in science, out of a total number of 146 in all faculties. No science scholarships are provided either by the city authorities or by private individuals, though fifty-six, spread over the other faculties, are available from these sources.

*The Doctorate of the University of Paris.*—Recognising that the systems of secondary education in other countries differ from those of France, and that in consequence foreigners are not able to rapidly pass the examinations necessary for the diploma of bachelor, which have hitherto been compulsory before proceeding to the doctorate, the Council of the University of Paris has modified the regulations governing the bestowal of its doctorate as far as foreigners are concerned. As the report makes clear, the imperfect knowledge of French and French literature possessed by most of these foreign students has also been taken into account, and for the future the bachelorship will not be considered indispensable. A foreigner may, without having taken the degree of bachelor at the University of Paris, be very strong in some subject or other. Why, asks Prof. Moissan, should he be prevented from taking the doctorate? The Council wish, as they say, to open their University to every type of mind; two things only are demanded of the aspirant to the doctorate—intelligence and work. No kind of official stamp will be insisted upon. This will lead the way, the Council very properly think, to what they regard as their chief duty the encouragement of scientific investigation. There is a large number of students at present in the science laboratories of the University itself, as well as those of the Pharmaceutical School, who are preparing theses for the new doctorate.

*New Gifts to the University.*—Many important gifts and bequests have been made to the University during the year.

(1) *Charles Legroux Prize.*—A donation of 10,000 francs, made by Madame Legroux, for the establishment of a quinquennial prize, to be awarded to the best work on the treatment and causes of diabetes.

(2) *Marjolin Legacy.*—The proceeds from property to be applied to paying the fees, for further terms, of French students of medicine who have been characterised for their zeal and exactness.

(3) *Mercet Donation.*—M. Émile Louis Mercet has given an annual amount of 3000 francs for six years, to be applied towards the salary of a secretary for a department of the Sorbonne.

(4) *Countess Chambrun Foundation.*—An annual gift of 5000 francs for thirty years towards the foundation of a course of study in social economics.

(5) *Anonymous Gift of* 50,000 *francs.*—This bequest was remitted to the Council by M. Lavisse. It brings an annual revenue of 2000 francs, which is to be devoted towards alleviating the needs of deserving French or foreign students.

(6) *Anonymous Gift of* 75,000 *francs for Travelling Scholarships.*—The anonymous donor proposes, if necessary, to renew this gift annually for three or four years. It is to be devoted to founding five travelling scholarships, each of the value of 15,000 francs. Two are to go to old students of the École normale supérieure, three to old students of the University. The choice of suitable students will be in the hands of the Council of the University on the report of a commission appointed by the Rector. The scholarship holders will employ some fifteen months in travelling round the world with the object of studying the social conditions, forms of government, &c., of different countries.

Of other important questions, such, for example, as an account of the work carried on in the laboratories and hospitals, the researches which have been made, and the technical applications arising therefrom, the errors rectified during the year, M. Moissan says space will permit him to say nothing. But there is more than enough in this interesting report to show that the University of Paris, with its 116 professors, to say nothing of lecturers, laboratory directors, and experimentalists, is doing a good work, and that its constitution in 1896, out of the older University of France, was fully justified. When it is borne in mind, moreover, that side by side with the instruction in science which is going on in the University, Paris possesses such large schools as the College of France, the Natural History Museum, the School of

Mines, the Normal School, the Polytechnic, the School of Fine Arts, the Pasteur Institute, the Central School and others, all engaged in a greater or less degree in imparting and advancing scientific knowledge, it will be seen that the provision for higher technical instruction in Paris is of the most satisfactory kind.

A. T. SIMMONS.

## *THE EXHIBITION OF RECENT ACQUISITIONS AT THE NATURAL HISTORY MUSEUM.*

It has already become recognised that collections of objects intended to be exhibited to the general public should be presented in such a way as to enable the visitor to obtain some systematised information. This one takes to be the so-called educational side of the question. Museum curators, however, although by necessity extremely conservative, are beginning to find themselves in a position not very different from that of the popular lecturer or writer of the day. Unless these have something new to offer, be it only the method, so to speak, of marketing their wares, they will fail to arrest the attention which, when once directed in the sought-for way, may never again be lost.

The curator, it must be pointed out, is in a worse plight than the others, for the lecturer's audience is a varying one, and the writer can change his public; while the museum, as one is accustomed to it, is a fixture. Again, whereas the hearing of a lecture or enjoyment of an article usually presupposes some amount of expenditure upon the part of the hearer or reader, on the other hand most museums are free; and there is a good deal of truth in the saying that what is paid for is appreciated more than that which is had for nothing.

A little living interest must always be an advantage to a museum, and there seems some likelihood that Prof. Ray Lankester's infusing of some into the natural history side of the British Museum may mark the beginning of a new era there.

Possibly the new departure may be of more direct value to the general public, who only pays for the Museum, than to the specialists who use the building; but let us consider the matter in detail.

The arched recesses opening out of the entrance hall have hitherto been assigned to the index collections. These were intended as a biological introduction to the main groups represented in detail in the galleries, but they have never been absolutely completed. Recently, indeed, some of the specimens have been taken away, possibly to reappear in a more suitable position at the head of the series they elucidate. More to the point is the fact, that their place in the last alcove but one on the right-hand side is now taken by "specimens recently acquired."

The collection which first arrests attention illustrates the remarkable molluscan fauna of Lake Tanganyika. There are three series of shells, two of which show the freshwater molluscs of the general type which inhabit the African lakes, as illustrated by representatives from Lakes Nyassa and Tanganyika. The third consists of shells from the latter piece of water, which belong to the series called halolimnic, by Mr. J. E. S. Moore, who has done so much to add to our knowledge of the Tanganyikan fauna, and who has started this month upon a second expedition to the Great Lakes of Africa. This naturalist has shown that the shells in question are almost identical with well-known Jurassic forms, and the chief interest surrounding this exhibit is that in many cases, side by side with the examples collected by Mr. Moore, are their fossil representatives. This reminds one forcibly of the arbitrary line drawn in the arrangement of the Museum between fossil and recent genera; but this by the way. As instances of the pairs of similar species might be quoted:

| Tanganyika. | Jurassic. |
|---|---|
| *Chytra kirkii.* | *Onustus ornatissimus*, Burton Bradstock. |
| *Bathanalia irridescens.* | *Amberleya orbignyana*, near Yeovil. |
| *Pseudomelania damoni.* | *Purpurina bellona*, Bradford Abbas. |
| *Limnotrochus thomsoni.* | *Littorina dorsetensis*, near Yeovil. |
| *Melania admirabilis.* | *Cerithium subscalariforme*, Bradford Abbas. |

Possibly the most striking exhibit is the collection of siliceous hexactinellid sponges dredged from Saguma Bay in Japan, and purchased by the Museum: many types and some of the finest examples yet known are among the number. They come from depths varying from 80 to 300 fathoms, and mention might be made of the fine *Euplectella imperialis* and *Rhabdocalyptus victor*, while the specimen of *Chaunoplectella cavernosa* is particularly beautiful.

The rare birds' skins presented by Dr. Moreno, the director of the Museum of La Plata, are as they were received. Indeed, it is rather agreeable to see exhibited in the Museum something which is not absolutely spick and span. An albino song-thrush from Argyll, presented by Colonel Edward Malcolm, finds a place by an example of one of the four recent species of *Pleurotomaria*, viz. *berichii*, all very rare and valuable, and the only living representatives of a genus once a thousand strong. The particular specimen contained the soft parts, and we are looking forward to an interesting paper based upon them from Mr. Martin Woodward, who gave a description of the radula to the Malacological Society the other day. A series of models illustrating the development of the chick within the egg attracted much attention on Easter Monday, as appertaining to something more or less familiar to the crowds whose acquaintance with oranges was even closer, judging from the heaps of peel not wholly left outside the building.

A formidable array of bottles contains a large collection of crustaceans exchanged with the Paris Museum, and chiefly obtained during the *Talisman* and *Travailleur* expeditions. Following close up, there is a second display of members of the same class from the Indian Museum. Lastly, must be mentioned several series of fish: one collected by Mr. Moore in the same lake as the shells; another representing a selection of the remarkable forms inhabiting the River Congo, presented by the Secretary of State for the Congo Free State, and recently described by Mr. G. A. Boulenger, with annals of the museum belonging to that republic. Many peculiarities of structure are to be met with; for instance, the curved snouts of the species belonging to the genus *Gnathonemus*, from which they take such names as *curvirostratus elephas* and *rhyncophorus*. The large teeth, too, of *Hydrocyon goliath* are most striking, fitting as they do between a pair of those in the opposite jaw, and coming to lie in deep grooves beyond their bases.

Two specimens of *Lepidosiren paradoxa*, sent by Mr. Graham Kerr from Paraguayan Chaco, complete the present list of the new exhibits.

Neglecting the actualities and possibilities of the Museum as a centre for research, it is primarily a storehouse in which everything, so far as space allows, is exhibited; a fact that enables the collector to name his specimens without unduly taking up the time of the staff. Secondly, the educational idea has been added to, but not combined with, this; while the popular interest will bear development, and it remains for the new director to work the various lines of usefulness into a well-balanced and harmonious whole.

WILFRED MARK WEBB.

## SURGEON-MAJOR G. C. WALLICH, M.D.

THERE passed away in his eighty-fourth year, at Nottingham Place, Marylebone, on March 31, George Charles Wallich, L.R.C.S. Ed., Surgeon-Major on the Retired List of Her Majesty's Indian Army; and in his decease zoology has lost an honest devotee whose work has left its impress on the progress of the science. He was the eldest son of Nathaniel Wallich, F.R.S., Knight of the Royal Danish Order of Dannebrog, distinguished during the early half of the century for his work on Indian botany, he being superintendent of the Botanic Gardens, Calcutta, where G. C. Wallich was born in November 1815. He was educated at Beverley in Yorkshire, at Reading Grammar School, and at King's College, Aberdeen, and the Edinburgh University, where he graduated M.D. in 1836, becoming the following year a Licentiate of the Royal College of Surgeons of that city. In 1838 he entered the Indian Army, and served as assistant-superintending surgeon in the Sutlej Campaign, and in 1847 he went through the Punjab wars, receiving the medal in commemoration of each. Eight years later he acted as field-surgeon during the Sonthal Campaign; and, invalided home in 1857, he two years afterwards settled at Guernsey, and afterwards at Kensington.

His scientific career dates from 1844, in which year he produced a paper dealing with "Some experiments tending to prove that the venous circulation is dependent on a vital act." His period of active and most continuous investigation, however, dates from the years 1858 to 1883, and his forty-eight papers produced during that time mostly deal with important questions of structure and distribution of the Protozoa, and allied organisms especially conspicuous in the leading topics in the marine biology of the time. Those which remain were devoted to the allied consideration of questions bearing on the formation of the sedimentary deposits formed by the lower organisms in both passing and past periods of the world's history, with here and there an occasional departure into the higher groups of animals. It was in the year 1860 that Wallich started upon the line of inquiry by which his authority was established. Being recommended by Sir R. Murchison and Huxley for the post of naturalist to H.M. *Bulldog*, about to survey the ground for the North Atlantic cable between Great Britain and America, he sailed under command of Sir F. L. McClintock, R.N., in June 1860, returning to London in November of that year. As the result of this voyage, he was the first to demonstrate that ocean depths below 1000 fathoms were actually inhabited. The facts concerning temperature, pressure, and the general conditions at these depths at the time known and surmised had led to the belief that animal life was thereat impossible, and Wallich, in proving the contrary, laid the foundations of our modern deep-sea research. Working out the soundings obtained during this memorable voyage, he later published the first part of a projected book, entitled "The North Atlantic Sea Bed," by which he became famous. Although never completed, this will remain a standard work in the literature of deep-sea investigation, and a lasting testimony to its author's acumen and powers of observation. While most fascinated by the geographical and lithological aspects of his task, Wallich was by no means neglectful of the more purely biological, and of the structure and physiological manifestations of the individual organism. Contemporary of the elder Carpenter, of Allman, and others who early in the latter half of the present century essayed the pioneer's task of unravelling the mysteries of life as revealed in their essence by the unicellular organism, his contributions towards the determination of the excretory nature of the contractile vacuole, and his attempt, at a period at which our micro-chemical methods were in their infancy, to differentiate the nucleus by means of an electric discharge, will always be interesting chapters in the history of physiological inquiry. Trenchant in his literary style, prone to discussion, we find him in controversy with his contemporary workers—conspicuously as concerning his views upon the "Bathybius," which Huxley, in later years, admitted his "bogey," and the Coccospheres, upon which recent investigation has proved his views to have been largely sound. He did well in his time, and his work will endure.

While neither distinction nor special recognition were meted out to him during the active years of his life, he was in 1898 awarded the Gold Medal of the Linnean Society of London, "in recognition of his researches into the problems connected with bathybial and pelagic life." He was an Hon. Fellow of the Microscopical Society, and a Corresponding Member of the Royal Society of Liége.

## NOTES.

IT is announced that, in accordance with the amended Standard Time Act, Adelaide time was advanced half an hour at midnight on Sunday.

WE learn from the *Astronomische Nachrichten* that the Fürstlich Jablonowskisebe Gesellschaft offers for 1902 a prize of 1000 marks for an essay bearing on Poincaré's investigations of Neumann's method of the arithmetic mean. The scope of the essays is defined by the society as follows:—That the investigations contained in Poincaré's work of 1896, entitled "La méthode de Neumann et le problème de Dirichlet," might be materially developed in some direction or other.

PARTICULARS concerning the work of the Belgian Antarctic Expedition have been given to the Brussels Geographical Society by Lieut. Gerlache, commander of the expedition. The *Times* gives the following summary of Lieut. Gerlache's report: The expedition left St. John's Bay on January 14, 1898, and on the 21st explored the South Shetland Islands. On January 15, in 55° 5′ south latitude and 65° 19′ west longitude, soundings to the depth of 4040 metres were taken. The *Belgica* left on the 23rd for Hughes Bay, discovering a strait separating the lands of the east from an unknown archipelago. The land to the east was named Danco Land. Magnetic observations were made and interesting botanical, geological, and photographic results were obtained. On February 13 the *Belgica* went in the direction of Alexander I Land, exploring the belt of bank ice towards the west. On March 10 the ship became fast in the ice in latitude 71° 34′, longitude 89° 10′. The sun disappeared on May 17, and there was continual night until July 21. M. Danco died on June 5, and his remains were deposited in a tomb of ice. The *Belgica*, after leaving her winter quarters, again became fast in the ice in 103° west longitude. She reached open water on March 14. The expedition made successful magnetic and meteorological observations, and obtained collections of pelagic and deep-sea fauna and samples of submarine sediments. On February 26 Black Island was explored, and on the following day the *Belgica* entered the Cockburn Channel, arriving at Punta Arenas, in Patagonia, on March 28.

AT the annual meeting of the members of the Royal Institution held on Monday, the Duke of Northumberland, President, presiding, it was announced that next month the Institution will complete one hundred years of its existence, the first meeting of its members in the building in Albemarle Street having been held on June 5, 1799. The managers have decided that this event, so interesting and memorable in the life of the Institution and in the history of science in this country, shall be duly celebrated.

They have, therefore, arranged for the delivery of two Commemoration Lectures. The first of these lectures will be delivered at three o'clock on Tuesday, June 6, by Lord Rayleigh, when His Royal Highness the Prince of Wales, Vice-Patron of the Institution, will preside and receive the honorary members; the second of these lectures will be delivered at nine o'clock on Wednesday evening, June 7, by Prof. Dewar, when His Grace the Duke of Northumberland, President of the Institution, will preside. It was further announced that the Lord Mayor has consented to give a reception to the members, foreign guests, and representative men, at the Mansion House, on the evening of Tuesday, June 6.

IN a brief reference to the recent scientific work of the Royal Institution, Prof. Dewar announced on Monday that having obtained liquid hydrogen in considerable quantity, he has directly determined its temperature and other physical constants, finding its boiling point to be much lower than was previously supposed, namely 20° above the zero of absolute temperature, and attaining by exhaustion a temperature of only 15° absolute. Pending the discovery in quantity of some yet lighter gas, there are no means within sight of bridging this gap and reaching the zero point. Prof. Dewar also took occasion to give a warning against the exaggerated accounts of the properties of liquid air, which, originating in America, have found their way into popular magazines in this country.

THE Trustees of the National Portrait Gallery have received, under the will of the late Colonel John Barrow, F.R.S., formerly of the Admiralty, a bequest of a series of portraits, painted for Colonel Barrow by Mr. Stephen Pearce, relating to the various expeditions in search of Sir John Franklin. The portraits comprise a large portrait-group representing "The Arctic Council" "discussing a plan of search for Sir John Franklin"; four large half-length portraits, representing Sir Robert McClure, Sir Leopold McClintock, Captain Penny, and Sir George Nares, each in the dress worn by him in the Arctic regions; fifteen small portraits of Sir Richard Collinson, Sir Henry Kellett, Sir Edward Belcher, Sir Edward Inglefield, Dr. John Rae, Captain Rochfort-Maguire, Captain J. E. Moore, Dr. Robert McCormick, Lient. J. Stewart, Lieut. Bellot, Sir Horatio T. Austin, Admiral Sherard Osborn, Dr. William Kennedy, Sir Leopold McClintock, and Sir Erasmus Ommanney.

THE Report of the Council of the Zoological Society, read at the seventieth anniversary meeting held on Friday last, stated that the number of Fellows on December 31, 1898, was 3185, showing an increase of twenty-seven during the past year, and that the number of Fellows on the roll of the Society was in excess of what it had been in any year since 1885. The principal new buildings erected in the Society's Gardens in 1898 were the Fellows' tea pavilion, the new llama-house, and the new zebra-house, all of which are well adapted to the purpose for which they were intended. The number of visitors to the Gardens was 710,948. The number of animals living in the Gardens at the end of the year was 2656, of which 818 were mammals, 1363 birds, and 475 reptiles and batrachians. Dr. John Anderson, F.R.S., Mr. W. E. de Winton, Dr. Charles H. Gatty, Sir Hugh Low, G.C.M.G., and Dr. Henry Woodward, F.R.S., were elected into the Council in the place of the retiring members, and his Grace the Duke of Bedford and Mr. Edward N. Buxton, elected into the Council since the last anniversary, were re-elected; also Sir William H. Flower, K.C.B., F.R.S., was re-elected President, Mr. Charles Drummond, Treasurer, and Dr. P. L. Sclater, F.R.S., as Secretary.

AT the annual general meeting of the Institution of Civil Engineers, held on April 26, Mr. W. H. Preece, C.B., President, in the chair, the result of the ballot for the election of officers was declared as follows: President, Sir Douglas Fox; vice-presidents, Mr. James Mansergh, Sir William White, K.C.B., Mr. Charles Hawksley, and Mr. John Clarke Hawkshaw; other members of Council, Mr. James Barton (Dundalk), Mr. Horace Bell, Sir Alexander Binnie, Dr. Henry Taylor Bovey, Mr. T. Forster Brown, Mr. W. R. Galbraith, Mr. George Graham, Mr. G. H. Hill, Mr. J. C. Inglis, Mr. Alexander Izat, Dr. Alex. B. W. Kennedy, F.R.S., Sir James Kitson, Bart., Mr. Anthony George Lyster, Mr. John Allen McDonald, Mr. E. Pritchard Martin, Mr. William Matthews, Sir Guilford Molesworth, K.C.I.E., Sir Andrew Noble, K.C.B., Mr. Alexander Siemens, Mr. Thomas Stewart, Mr. John I. Thornycroft, F.R.S., Mr. William Thwaites, Mr. F. W. Webb, and Sir E. Leader Williams.

THE Royal College of Surgeons of England has unsuccessfully appealed against the decision of the Court of Queen's Bench upon the subject of its liability to property duty in respect of part of the property held by it for the public objects of the institution. A strong protest is made against this result in the *Lancet*. It is pointed out that the College is a body incorporated by Royal Charter, the object being the "benefit of the common weal of this kingdom by the promotion of the art and science of surgery and the due promotion and encouragement of the study and practice of the said art and science of surgery." To the attainment of this object all its funds are legally appropriated and actually applied; nevertheless, the courts have decided to exclude the College from the benefits of an exception created by the Act of Parliament in favour of "any property legally appropriated and applied for . . . the promotion of science." The decision distinguishes between the museum and the library in Lincoln's Inn, and while it protects the museum as being devoted to the promotion of the science of surgery, the library is regarded as for the private convenience or advantage of the members of the College. The *Lancet* points out that eight or nine years ago the question arose as to whether the Institution of Civil Engineers was, in circumstances almost precisely parallel to those of the Royal College of Surgeons at the present day, liable to the same duty. Fortunately for that institution, the House of Lords held that applied science, no less than the pure sciences, fell within the meaning of the Act, and sustained the claim to exemption in spite of the professional eminence and social success of its members. The Royal College of Surgeons is less fortunate in its present situation.

THE death is announced of Dr. C. Brongniart, Paris, distinguished by his entomological works, and more especially by his memoir on fossil insects of the Primary period.

ACCORDING to a despatch from St. Louis a very destructive cyclone swept over Kirksville, Missouri, on Thursday last. The storm broke about 6.30 p.m. with great fury, sweeping a path a quarter of a mile broad through the eastern portion of the town, four hundred buildings being demolished. Heavy rain followed, accompanied by intense darkness.

DR. LUDWIG BÜCHNER, of Darmstadt, the author of "Kraft und Stoff" (1855), a work which did much to popularise scientific materialism in Germany, died on Monday, at seventy-five years of age. Dr. Büchner was one of the most meritorious popularisers of natural science in Germany, and greatly assisted in diffusing a knowledge of the Darwinian theories in the Fatherland.

THE death is announced of Mr. Charles Leeson Prince, of Crowborough, Sussex, whose meteorological work has on several occasions been referred to in these columns. Mr. Prince was a member of the Royal College of Surgeons, and a licentiate of the Society of Apothecaries. For many years

he had taken great interest in all questions relating to meteorology. He was a Fellow of the Royal Astronomical and of the Meteorological Societies, and a member of the Scottish Meteorological Society, and the author of several papers on the meteorology of Uckfield and Crowborough Hill.

Mr. Akers-Douglas, M.P., the First Commissioner of Works, speaking at Whitstable-on-Sea on Thursday last, referred to the favourable reports by the medical inspectors on the Whitstable oyster beds, and said that the promised legislation has not been forgotten. The President of the Local Government Board, with a desire to set at rest the fears regarding the eating of oysters, and to protect a *bona-fide* industry, is about to introduce a measure providing for the inspection of oyster layings, prohibiting removal from insanitary grounds, and regulating the importation of foreign oysters from suspected districts.

Reuter reports that the President of the Geographical Society at Christiania has received a letter from M. Borchgrevink, dated Cape Adair, Victoria Land, February 28, in which he says:—"I have now landed on the great Australian continent with staff, instruments, and seventy-five dogs. The greatest discipline has prevailed throughout."

From the current number of the U.S. *Monthly Weather Review* (for December last) we learn that the important decision has been taken of correcting all the published barometrical values for gravity from January 1, 1899. This change has been found necessary owing to the recent extensions of the Weather Bureau in the West Indies and along the South American coast. The reduction to standard temperature has been practised for the last sixty years, but the reduction to standard gravity has been applied only in special cases; and although the amount of the correction is now usually stated at the head of meteorological tables in the same way as the latitude and longitude and height above sea-level, the general application of the correction to the individual readings has been delayed until a concert of action among all nations could be arrived at. Its importance, however, has been recognised by various meteorological conferences. In the latitude of London the correction to standard gravity of latitude 45° amounts to about + ·02 inch.

The Report of the Kew Observatory Committee of the Royal Society has been published for the year 1898. In the section referring to terrestrial magnetism, it is stated that two magnetic storms, or periods of considerable disturbance of the needles were registered, viz. on March 14–15 and on September 9–10. The first storm was the largest recorded since August 1894, and both were presumably associated with the aurora simultaneously seen in the British Isles. One of Prof. J. Milne's seismographs, intended to measure the tilting of the ground along an east–west line, was erected in the early part of the year. The largest tremors were recorded on June 29, August 31, and November 17. Among the experimental work carried on during the year may be specially mentioned that relating to atmospheric electricity, aneroid barometers, and platinum and mercurial thermometry. The verification of instruments of various kinds has steadily increased, the number tested during the year exceeding 24,000. Although the number of watches sent for trial was less than in the previous year, the high standard referred to in previous reports has been maintained. During the year, various schemes have been promoted in connection with electric tramways in the neighbourhood of the observatory. The Committee state that whilst everything has been done, as far as can be foreseen, to protect the magnetographs, it is impossible to contemplate the future without some misgivings. The proposed establishment of a National Physical Laboratory will, in all probability, greatly extend the usefulness of the Kew Observatory; the arrangements were not completed before the close of the year 1898.

The members of the German Deep Sea Expedition arrived in Hamburg on Saturday, on board the *Valdivia*, after nine months' absence. They were welcomed (the *Times* reports) by the Imperial Secretary of State for the Interior, Count von Posadowsky, the Saxon Minister of Education, Baron von Seydewitz, Prof. Drygalski, who will be the leader of the German Antarctic expedition, and a large number of the representatives of the scientific world. At a banquet given in the dining-hall of the offices of the Hamburg-American Line, Count Posadowsky welcomed the members of the expedition in a speech in which he referred to the interest manifested by the Emperor in the expedition and in all seafaring projects. This was not due solely to his Majesty's personal inclinations, but resulted from his profound recognition of the importance of these subjects for the future of Germany. A telegram was read in which the Emperor expressed his satisfaction at the success of the expedition.

Dr. R. H. Scott, F.R.S., gives in the *Quarterly Journal of the Royal Meteorological Society*, dated January 1899 and just issued, a translation of the important paper on the diurnal oscillation of the barometer, contributed by Dr. Julius Hann to the *Meteorologische Zeitschrift* for October 1898. Meteorologists unfamiliar with the German language will be glad to have this English version of Dr. Hann's contribution to the theory of the daily barometric oscillations.

As an indication of the character of the season, Mr. W. Baylor Hartland, writing from Cork, says his son saw swallows on Wednesday last, April 26, at Ard-Cairn. On Thursday he himself saw a pair of corncrakes nestling among some daffodil beds. Mr. Hartland adds: "If this had occurred in a field of rye, wheat, rye-grass, or vetches, I should not have noticed it. But for the birds to nestle within the foliage of broad plantations of daffodils, planted for commercial purposes in Ireland, never before happened in the Green Isle. I have grown them for eighteen years, but the foliage this year is so luxuriant, I suppose the birds were attracted by its shelter."

A Parliamentary Return just issued shows that between the date of the passing of the Vaccination Act on August 12 and December 31, 1898, the number of certificates of conscientious objection received by the vaccination officers was 203,413, and that the number of children to whom such certificates related was 230,147.

It is stated by the *Allgemeine Militär-Zeitung* that the aluminium steerable balloon invented by Count Zeppelin will very probably make its first ascent at the beginning of July. The ascent will take place above Lake Constance. In order that the balloon may rise clear of trees and buildings, a platform has been built in the lake on pontoons, at about 700 metres from the shore, where the apparatus for raising the balloon will be placed.

In a paper on the treatment of refractory silver ores by lixiviation, read by Mr. Breakell at a recent meeting of the Institution of Mining Engineers, some results are given which bear strong testimony to the value of Russell's modification of the hyposulphite process. Experiments are described proving that the presence of only 0·2 per cent. of copper increases the volatilisation loss of silver in chloridising roasting. In one case the loss was raised from 0·5 to 3·6 ounces of silver per ton by the addition of this amount of copper. On the other hand, metallic silver and sulphide of silver, which are always present, especially in badly roasted charges, are readily dissolved

by hyposulphite solutions containing copper, though not rapidly acted on in its absence. It follows that the presence of copper should be avoided in the furnace charge, and that it may be added with advantage in the later stages of the process.

The old view that insects, with all the lower animals, were created for man's benefit cannot reasonably be held at the present time, but it must, nevertheless, not be forgotten that there are very many beneficial as well as injurious insects. Dr. L. O. Howard has recently summed up the good and bad qualities of insects so far as it is possible to do, and he finds that the insects of 116 families are beneficial, and the insects of 113 families are injurious, while those of 71 families are both beneficial and harmful or their functions have not been determined. The injurious insects are made up of 112 families which feed upon cultivated or useful plants, and one family the members of which are parasitic upon warm-blooded animals. Of the beneficial insects, those of 79 families are valuable as preying upon other insects, 32 families are of service as scavengers, two families as pollenisers, and three families as forming food for food fishes.

Prof. F. E. Schulze, of Berlin, the general editor of the important new German work, "Das Tierreich," which is in course of publication by Messrs. R. Friedländer and Son, has obtained the services of Prof. Kretschmer, of Marburg, for the preparation of a series of rules for the formation and pronunciation of zoological and botanical names upon classical and orthodox principles. These rules seem to be excellent in every way, and will, we trust, be strictly followed by the numerous contributors to "Das Tierreich." In America, we regret to say, a small school of zoologists has arisen who prefer to spell and pronounce names *in*correctly, following literally the mistakes often made by their original propounders. This pestilent heresy has, we are glad to say, not met with much support in Europe, and we hope that Prof. Kretschmer's rules will assist in suppressing it.

In the "Report of the Entomological Department of the New Jersey Agricultural College Experiment Station for the year 1898," Dr. John B. Smith calls attention to the interesting and perhaps important fact that the San José scale now begins breeding later than when it first came under his observation, and that the rate of increase before midsummer is materially less than in the past, the period of greatest increase being now in September. It is evident that the introduced pest is endeavouring to accommodate itself to its new surroundings, and it will be interesting to see whether it succeeds or fails. If it fails, its automatic extinction will be a mere matter of time, though it is quite possible that it may be capable of producing a great amount of harm before that time arrives.

A recent number of the *Cape Agricultural Journal* contains a report of an address given by Dr. Edington on the artificial use of a particular fungus, said to be parasitic to locusts, for the destruction of the latter. The results so far obtained with the fungus in question appear to be at considerable variance, some farmers stating that they have derived great benefit from its application, whilst others assert as positively that it has been of no use whatever. A great deal must of necessity depend upon the circumstances in which this, together with other such similar living-destroying agencies, are employed, and Dr. Edington, in the course of his lecture, pointed out what he considered the best methods for promoting the successful use of this fungus. If locusts can be destroyed in so simple a manner as this is described to be, the gain to the Cape farmers will be enormous, and at any rate means should be adopted so that its use may become more widely known, and more extensive trials given to it. The use of fungi for the destruction of pests is being tried in America, where the white muscardine fungus, *Sporotrichum globuliferum*, has been largely employed during the last few years to check the injurious over-production of the chinch-bug. Mr. Benjamin Duggar, of the Cornell Agricultural Experiment Station, has, however, been recently making a careful study of this organism in relation to the insect in question, and has come to the conclusion that, although it is undoubtedly parasitic at times, it is not sufficiently efficient to enable it to be artificially employed with economic success. It is obvious that to obtain trustworthy data on this subject, many and very carefully conducted investigations must be carried out. It is to be hoped that Dr. Edington will be able to give the locust-problem the time and attention which it requires to enable scientific conclusions to be drawn as to the economic value of the fungus he recommends in destroying locusts.

The current number of the *Journal of the Sanitary Institute* continues the reports of papers read at the congress held in Birmingham last year. Amongst them we note a useful little address given by Dr. Mary D. Sturge in the Section devoted to domestic hygiene, entitled "The Claims of Childhood." Whilst emphasising the responsibilities of parents towards their offspring, the writer also points out the necessity of our following the example of France in getting legislative measures directed towards checking the growing use of tobacco amongst young boys. In Norway only last year, it appears, stringent laws were passed forbidding the sale of tobacco to lads under sixteen, and prohibiting their smoking in the streets. Although the municipal authorities in most of our large crowded cities are alive to the duty of modifying as far as possible the unfavourable conditions under which children are of necessity reared, yet much remains still to be done. Dr. Sturge, amongst other matters, calls attention to the smoke-nuisance, and indulges in the hope that some day legislative steps will be taken whereby it will be controlled, and incidentally tells us that in the Tudor period a law existed ordering Londoners to burn nothing but wood during the time that Parliament was sitting, in order that the health of the country squires who came to town might not be impaired!

Mr. William H. Dall has prepared a useful table of the North American Tertiary horizons, correlated with one another and with those of Western Europe (Eighteenth Annual Report of the U.S. Geological Survey, 1898).

The geology of the eastern part of Texas, with reference to the artesian wells, forms the subject of an essay by Mr. Robert T. Hill and Mr. T. Wayland Vaughan (Eighteenth Annual Report of the U.S. Geological Survey).

MM. E. Piette and J. de la Porterie describe some prehistoric remains from excavations at Brassempouy, south-east of Dax, Department of Landes. Drawings on bones and various finely-worked implements are figured (*L'Anthropologie*, Paris, tome ix).

The Triassic formation of Connecticut is very fully discussed by Prof. William M. Davis (Eighteenth Annual Report of the U.S. Geological Survey). He treats the subject from three points of view—deposition, deformation, and denudation. The formation comprises a great series of sandstones and shales, with local conglomerates; and it includes in the central division great sheets and dykes of volcanic rock. In mass the formation is of "continental" as opposed to marine origin.

The origin of peneplains is discussed by Prof. W. M. Davis in an article in the *American Geologist* for April. The article is in the main a reply to criticisms by Prof. Tarr. It is maintained that the prolonged results of both marine abrasion and subaerial denudation tend to reduce the land to a base-level (or peneplain)—a nearly featureless plain, a little below or a little above sea-level. It is admitted, with regard to ancient plains of

denudation, that in many instances there seems to be no way of determining how much work was done by the sea, and how much had been previously done by rivers, rain, and similar agencies.

"THE Alkali Soils of the Yellowstone Valley" forms the subject of an essay by Messrs. M. Whitney and T. H. Means (U.S. Department of Agriculture, *Bulletin* No. 14, 1898). In the Western States of America, any excessive accumulation of soluble mineral salts in the soil is popularly spoken of as "alkali." These salts include sodium carbonate, sulphate and chloride, magnesium sulphate and chloride, and occasionally some of the borates. They may be traced to the sandstones, shales, and slaty rocks from which the soils have been derived. Before irrigation was introduced, the salts were present in rather large amounts, but they were well distributed throughout the soil, and not in such large quantities as to be injurious to crops. The injury is due entirely to over-irrigation, and may, in the authors' opinion, be easily remedied.

WE learn from the *Botanical Gazette* that the University of Texas has established a distinct department of botany, which will begin its separate existence with the next college year. The new department will be placed under the charge of Dr. W. L. Bray.

MR. F. J. HANBURY and Rev. E. S. Marshall announce for early publication their long-promised "Flora of Kent," which has been twenty years in preparation. From its variety of soil, its geographical position, and its extended sea and river coast, this will be one of the most interesting and richest county floras of England. There will be two maps, one showing the divisions of the county, and the other coloured geologically; and in the introduction, devoted to the topography of the county, there will be sections assigned to geology and meteorology.

THE study of natural history has been greatly stimulated in this country by the meetings, the excursions, and the publications of local societies. We have before us the *Irish Naturalist* for April, with a paper on the botany of the Great Central Plain of Ireland, by Mr. R. Ll. Praeger, and the conclusion of one on the Brachiopoda and Mollusca of the carboniferous rocks of Ireland, by Dr. A. H. Foord; also the *Halifax Naturalist* for April, containing a paper on the crocus leaf, by Mr. C. E. Mass, and one on the Halifax fish fauna, by Mr. E. D. Wellburn, as well as an instalment of Mr. W. B. Crump's flora of Halifax.

AMONG the more interesting articles in the *Journal of the Royal Horticultural Society* for April is an account of a visit to Naina Tal, Kumaon, the summer residence of the Lieut.-Governor of the North-West Provinces of India; and one on the Botanical Garden at Padua, founded in 1545, and said to be the oldest in the world. It contains some trees of remarkable antiquity, one of *Vitex agnus-castus*, 349, one of *Chamaerops humilis*, 314, and one of *Platanus orientalis*, 219 years old; besides a number that have more than completed the century. Several of these are figured. There is a specimen of *Salisburia adiantifolia*, 148 years old, in which grafts from the female have been inserted on the original male plant, so that it produces both male and female flowers.

MR. BERNARD QUARITCH has published a catalogue containing descriptions of 1781 works of geography, voyages, travels, history of America, Africa, Australasia and Asia, and of books on the languages of America, Africa, and Oceanica, offered for sale by him.

THE fourteenth part of Mr. Oswin A. J. Lee's "Among British Birds in their Nesting Haunts" (Edinburgh: David Douglas) contains ten magnificent plates illustrating the nests of the turtle-dove, barn owl, reed warbler, tree sparrow, stone curlew, partridge, tufted duck, jay, and kingfisher.

FOUR different kinds of species are considered by Mr. O. F. Cook in the *American Naturalist*; they are enumerated as follows: (1) The phylogenetic species, a division or section of a line of biological succession; (2) the insular or segregated species, the living end of a line of the preceding category; (3) the incipient species, preferably known as a sub-species; (4) the artificial species, the result of man's interference in nature. Mr. Cook considers that the designation "species" should be reserved for its original use with the second of these categories, and the use of the popular designation "variety" should be restricted to the fourth. He criticises classification according to "amount of difference," and points out that with this as the only criterion, "fossils, geographic races, and artificially produced varieties are being catalogued miscellaneously and indiscriminately as species."

IN a note communicated to the *Atti dei Lincei*, viii. 5, Dr. A. Pochettino describes the results of certain observations made with acoustic resonators with a view of determining in what manner the modulus of decay is affected: (1) by varying the shape of the aperture, keeping its area constant; (2) by furnishing the aperture with flanges of various sizes; (3) by varying the distance between the resonator and the excitor. Dr. Pochettino finds that by increasing the diameter of the flange the modulus of decay diminishes; or, in the first place, the resonator becomes more capable of reinforcing vibrations of its own period, and at the same time becomes less sensitive to vibrations slightly differing in period, in the second place, the vibrations, when once excited, last longer. The modulus of decay also decreases when the distance between the excitor and resonator is increased. In experimenting with elliptic and circular apertures, the moduli of decay were found to be very nearly equal.

THE second volume of the second edition of Prof. H. Weber's masterly "Lehrbuch der Algebra" has just been published by Messrs. F. Vieweg and Son, Brunswick. The two original volumes have already been reviewed in detail in NATURE (vol. lv. pp. 25 and 481, 1897), so it is unnecessary to do more than announce the completion of the second edition of this standard treatise.—The third edition of "Premiers principes d'Electricité industrielle," by M. Paul Janet, has been published by Messrs. Gauthier-Villars, Paris. The original work contained the substance of lectures delivered in Grenoble in 1892, under the auspices of the municipality of that city. So many advances have taken place in applied electricity since the lectures were given that a number of alterations and additions have been necessary in order to bring the volume up to date.—Mr. William Schooling has revised and extended "Inwood's Tables of Interest and Mortality, for the Purchasing of Estates and Valuation of Properties," and Messrs. Crosby Lockwood and Son have just published the new edition (the twenty-fifth) containing extensive additions made by him The whole work appears to have been very carefully revised, and it now forms an instructive as well as serviceable collection of tables. A table of logarithms of natural numbers has been introduced, and also M. Fédor Thoman's logarithmic tables of compound interest and annuities. From the point of view of practical mathematics, the new edition of "Inwood" is distinctly in advance of the former issues.

THE additions to the Zoological Society's Gardens during the past week include a Feline Dourocouli (*Nyctipithecus vociferans*) from South Brazil, presented by Mrs. Firman; a Common Raccoon (*Procyon lotor*) from North America, a Pine Marten (*Mustela martes*), British, presented by Master Eric Mellin; an Indian Pigmy Goose (*Nettopus coromandelianus*, ♂) from India, presented by H.G. the Duke of Bedford; three Ostriches (*Struthio camelus*, 3 ♀) from Lagos, presented by Mr. G. F. Abadie; a Macqueen's Bustard (*Houbara macqueeni*) from

Western Asia, presented by Mr. B. T. Ffinch; two Double-banded Sand-Grouse (*Pterocles bicinctus*) from Senegal, a Lesser Pin-tailed Sand-Grouse (*Pterocles exustus*) from North Africa, presented by Mr. W. H. St. Quintin; a King Parrakeet (*Aprosmictus cyanopygius*) from Australia, presented by Mr. C. D. Chambers; a Delalande's Gecko (*Tarentola delalandii*) from West Africa, presented by Miss Shenton; a Rhesus Monkey (*Macacus rhesus*, ♂) from India, a Great Kangaroo (*Macropus giganteus*, ♂) from Australia, a Salvadori's Cassowary (*Casuarius salvadorii*), a Blue-necked Cassowary (*Casuarius intensus*) from New Guinea, a Beccari's Cassowary (*Casuarius beccarii*) from South-eastern New Guinea, five Oblong Chelodines (*Chelodina oblonga*) from Australia, a Derbian Sternothere (*Sternothaerus derbianus*) from West Africa, a Blackish Sternothere (*Sternothaerus nigricans*) from Madagascar, two Black-necked Swans (*Cygnus nigricollis*) from Antarctic America, deposited.

## OUR ASTRONOMICAL COLUMN.

COMET 1899 *a* (SWIFT).—This comet having now passed considerably to the west of the sun, it is possible that it may be observed in the eastern sky before sunrise. The following ephemeris is given by Herr H. Kreutz in *Astr. Nach.* (Bd. 149, No. 3556):

*Ephemeris for 12h. Berlin Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ | Br. |
|---|---|---|---|
| May 4 | 23 57 45 | +25 17·9 | 1·74 |
| 5 | 53 54 | 26 17·3 | 1·69 |
| 6 | 49 53 | 27 19·3 | |
| 7 | 45 41 | 28 24·0 | 1·67 |
| 8 | 41 17 | 29 31·5 | |
| 9 | 36 40 | 30 42·0 | 1·66 |
| 10 | 31 45 | 31 55·7 | |
| 11 | 26 28 | +33 12·7 | 1·66 |

During the week it moves in a north-westerly direction from between Ψ Pegasi and α Andromeda, and is now rapidly decreasing in brightness as it recedes from the sun.

TEMPEL'S COMET (1873 II.).—The following ephemeris is given by M. L. Schulhof in *Ast. Nach.* (Bd. 149, No. 3554):—

*Ephemeris for 12h. Paris Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ ″ | Br. |
|---|---|---|---|
| May 4 | 18 48 57·0 | −4 42 8 | 0·460 |
| 5 | 50 39·5 | 4 37 57 | |
| 6 | 52 21·5 | 4 33 51 | |
| 7 | 54 3·2 | 4 29 51 | |
| 8 | 55 44·5 | 4 25 58 | 0·521 |
| 9 | 57 25·5 | 4 22 13 | |
| 10 | 18 59 6·0 | 4 18 33 | |
| 11 | 19 0 46·1 | −4 15 3 | |

During the week the comet moves slowly north-eastwards through the northern portions of Scutum Sobieski, and should be looked for in the early morning.

SECOND WASHINGTON STAR CATALOGUE.—Appendix I. to the Washington Observations of 1892 has recently been issued, and is devoted to the publication of the catalogue of standard stars which has been compiled from the work done with the transit circle of the U.S. Naval Observatory during the last thirty years. The instrument was made by Pistor and Martins, of Berlin, and was used almost continually from January 1866 to June 1891, being successively under the charge of Profs. Newcomb, Hall, Harkness, and Eastman. Prof. J. R. Eastman, who had the direction of it from 1874 to 1891, has had almost entire charge of the catalogue, and it is therefore issued in his name. Of the 72,914 observations embodied in the book, 17,334 were made by him personally and 39,867 under his immediate supervision.

The first half of the volume is occupied by descriptions of the apparatus and methods of reduction of the observations. Next come the tables of annual results; then a catalogue of stars employed in the American Ephemeris. The general catalogue, with which the book concludes, gives data for 5151 stars, all for the epoch 1875·0.

SPECTRA OF STARS OF CLASS III. *b*.—Prof. W. C. Dunér, of the Upsala Observatory, has been revising his survey of the red stars by means of the new Steinheil refractor, erected there in 1893. This has a visual objective of 36 cm. aperture, and a photographic objective of 33 cm. aperture. All the spectroscopic observations have been made with ocular spectroscopes of the Zöllner type, with dispersions varying from 3°·5 to 10° from C to G (*Astrophysical Journal*, vol. ix. p. 119, 1899).

In most cases, the previous results were confirmed, but in several of the brighter stars of this class he has found additional features. In all the brighter stars the band 5 (λ 576) is seen to be double, while near to the less refrangible edge of band 6 (λ 5636) a bright band is seen. Additional confirmation of the reality of these details is provided by the photograph of the spectrum of 132 Schjellerup in the *Astrophysical Journal*, vol. viii., which clearly shows a bright line at λ 5595. Variations in the relative intensities of the bands are common, notably in the case of bands 6 (λ 5636) and 4 (λ 586). In 152 Schj., the brightest of this class of stars, band 6 and 9 are very bright, while band 4 is quite faint. In 280 Schj. band 4 is the strongest in the spectrum, while band 6 is scarcely visible. Prof. Dunér thinks that, by a closer attention to these variations, a classification of these red stars would be rendered possible.

## LEAD COMPOUNDS IN POTTERY GLAZES.[1]

IT has been known for some months that Prof. T. E. Thorpe, F.R.S., and Prof. T. Oliver, had been commissioned by the Home Secretary to investigate the use of lead compounds in the production of pottery glazes and colours, and to suggest means which might be adopted to counteract the evils admitted, on all hands, to follow from their use. It had been found considerably easier by those who had drawn public attention to these evils even to exaggerate them, grave as they were, than to devise remedies which had any chance of practical adoption at the hands of the trade. The scientific eminence of Profs. Thorpe and Oliver, and their practical acquaintance with the details of many manufacturing processes, warranted the opinion that the choice of the Home Office was a wise one. The appearance of their report marks a very welcome stage in the treatment of this troublesome and intricate question. There exists in this country a pottery industry of considerable dimensions, producing pottery wares of infinite variety, and supplying, not merely the demands of our own country, but possessing, probably, a larger export trade than that of any similar industry in the world. This industry has been built up on the practical experience of generations of workers in the same business. The methods in use may appear, in many cases, to be the reverse of scientific; but, at all events, they have sufficed for the production of pottery of excellent make and finish, at a price which enables our potters still to hold their own, in spite of the efforts of their foreign rivals to copy their methods, their shapes, and their designs. It is idle for any one to deny the fact that, for pottery such as forms the bulk of our productions, glazes containing lead compounds are the simplest and the most trustworthy, and best fulfil all the requirements of a difficult and complicated manufacture. It is admitted, however, that lead compounds, used in the form and proportions common in English practice, may, and often do, cause serious illness and suffering—amounting in extreme cases to blindness, paralysis, and death—to those employed in certain of the processes of pottery production. Regulations have been framed from time to time by the Home Office, designed to minimise these evils. The latest proposals of this kind, which came into force only at the end of last year, deal with the removal of dust from work-rooms; the provision of means by which dust containing lead compounds shall be kept from the face of the worker; the provision of overalls and head coverings, as well as adequate and convenient washing accommodation for all workers who come in contact with lead compounds; and last, but by no means least, provide for a compulsory monthly medical examination of all women and young persons employed in certain specified occupations. These regulations, which are set out in full on pp. 43–45 of the report, are in startling contrast with the official regulations in force in foreign countries. While foreign Governments have for the most part either made

[1] Report to Her Majesty's principal Secretary of State for the Home Department on the employment of Compounds of Lead in the Manufacture of Pottery. By Prof. T. E. Thorpe, LL.D., F.R.S., and Prof. Thomas Oliver, M.D., F.R.C.P.

no regulations at all, or have confined themselves to benevolent advice (see report, pp. 46–50), we have in this country adopted, on the initiative of the Home Office, and with the assent of manufacturers, regulations on the points named above, which cannot fail to diminish the more serious evils complained of. Doubtless the pottery manufacturers will be grateful to Profs. Thorpe and Oliver for establishing this point.

It was felt, however, that important and valuable as such regulations may be, they leave untouched the kernel of the whole question. The terms of reference contained in the letter from the Home Secretary inviting the co-operation of Prof. Thorpe put the matter very clearly: The Secretary of State desires to ascertain (1) how far the dangers may be diminished or removed by substituting for the carbonate of lead, ordinarily used, either (*a*) one or other less soluble compounds of lead, *e.g.* a silicate; (*b*) "leadless" glaze; (2) how far any substitutes found to be harmless or less dangerous than the carbonate, lend themselves to the varied practical requirements of the manufacturer; (3) what other preventive measures can be adopted.

The report sets forth in a clear, simple, and decided form the conclusions arrived at on these points. It furnishes an account of visits paid to various pottery works on the continent. Results are given of the analytical determination of the proportion of lead compounds in glazes collected from a number of potteries in this country. Valuable tables are also given as to the solubility of various lead compounds, and of certain pottery "fritts" and glazes containing lead, in dilute, hydrochloric, and acetic acids; and, *inter alia*, we find that Prof. Thorpe has discovered in the course of his investigations a compound silicate containing 22 per cent. of lead oxide, which, he says, is insoluble in dilute acids. We are also furnished with the considerations and arguments on which the Professors have based their recommendations.

The recommendations themselves are four in number, and may be summarised as follows:—

(1) The prohibition of lead compounds entirely in the glazes used on seven-tenths of the wares produced in the potteries.

(2) That in all other branches of the pottery industry lead shall only be used in the form of a fritted compound silicate.

(3) That the use of raw lead—*i.e.* white lead—in glazes or colours should be absolutely prohibited.

(4) That the employment of women and young persons as dippers, dippers' assistants, ware cleaners after dippers, and glost placers should be prohibited in all factories where glazes containing lead continue to be used.

That these conclusions, if carried into effect, would do away with lead-poisoning in the pottery industry, there can be no two opinions. That the first and fourth of them, if insisted on in the present state of our knowledge, would cause, not only a serious dislocation of the pottery industry, but the transference of some of it to our foreign rivals (who are, for the most part, under no restrictions whatever as to their use of lead compounds or female labour), there can also be little doubt. Even in view of such circumstances, the adoption of these conclusions might be considered advisable, if an impartial consideration of the facts stated in the report showed that no other conclusions would meet the case. It is necessary, therefore, to consider whether the conclusions arrived at by Profs. Thorpe and Oliver are justified by the information given in the report. It may be said at once that a careful consideration of the report leads one to the conclusion that they are not.

The facts contained in the report may be summed up as follows:—

(1) English potters, generally speaking, use glazes containing "raw," *i.e.* "unfritted" white lead. This compound finds its way into the system, and being readily soluble in the gastric juice produces an excessive amount of lead-poisoning.

(2) Women and young persons are stated to be more susceptible to lead-poisoning in this way than adult males. The figures quoted are open to other interpretations.

(3) Leadless glazes are being tried by several manufacturers in this country on a limited scale. The results obtained so far may be described as satisfactory; but that they have been tried on an adequate scale, and under widely varying conditions, there is not sufficient evidence to prove.

(4) Certain foreign manufacturers, producing pottery similar to that produced in this country, have abandoned the use of "raw" white lead in their glazes.

(5) The glazes stated in the report to be used by these manufacturers contain as large a percentage of lead monoxide as is contained in the glazes used for similar purposes in this country.

(Compare table 1 on page 38 of the report, giving the percentages of lead monoxide found in certain earthenware glazes used in Staffordshire, with the percentages of lead oxide found in the foreign glazes, mentioned on pp. 16–25 of the report.)

(6) The lead compound used in these foreign glazes is either a bisilicate of lead ($PbO2SiO_2$), or a compound silicate containing as bases oxide of lead, alumina, lime, and alkalies (report, pp. 16–25).

(7) Wherever these compounds have been introduced in place of white lead, lead-poisoning has disappeared (report, see pp. 17, 18, 20, 25).

(8) The foreign manufacturers above mentioned use "leadless" glazes no more than English potters do.

(9) Women and young persons are employed at these factories as dippers, dippers' assistants, ware cleaners after dippers or glost placers, and yet there are no cases of lead-poisoning.

The statements thus briefly presented are an accurate summary of the information contained, on these points, in the report, and it is evident that they furnish no warrant for the first and fourth conclusions arrived at by Profs. Thorpe and Oliver. No one doubts that it would make assurance doubly sure to prohibit the use of lead in the glazes used on seven-tenths of the pottery produced in the "potteries" district of Staffordshire. The report contains very little evidence to show that such a cutting of the Gordonian knot is practicable, while it furnishes ample evidence that so drastic a regulation is not required to abolish "plumbism." English potters, from the time of Josiah Wedgwood down to the present, have made numberless experiments to produce leadless glazes. In a paper by Mr. W. P. Rix, published in the *Journal* of the Society of Arts of March 3, 1899, an account is given of the best known of these, and it is shown clearly that in almost every case their use has been abandoned, in some cases after a very lengthy trial, because of practical difficulties connected with their production, which made them too uncertain for general use. The experiments to which Profs. Thorpe and Oliver refer on p. 9 of their report are too recent and too incomplete to afford any justification for the sweeping statement made on that page in the following words, the italics being mine:—

"We have no doubt whatever that leadless glazes, of sufficient brilliancy, *covering power*, and durability, and adapted to all kinds of table, domestic, and sanitary ware, are now within the reach of the manufacturer."

As a matter of fact, it is known to every practical potter who has experimented with leadless glazes, and to none better than those who are working with them at the present time, that leadless glazes of sufficient stability—*i.e.* containing a sufficiently high percentage of alumina to bring them into agreement with the ware—do not become fluid (or "flow," as the potter calls it) in the firing to the same extent that lead glazes do. They are, consequently, deficient in that "covering power," as a potter understands the term, that Profs. Thorpe and Oliver claim for them.

At the general firing temperature of English earthenware glazes, a leadless glaze, even of the very latest type, becomes clear and glossy, but it does not become fluid. It follows from this, that the slightest inequality of thickness produced in the dipping remains after firing; that any small bit knocked or chipped out of the glaze coating before it is fired—an accident of the most ordinary occurrence—leaves a bare spot, for the glaze cannot flow over the space as a lead glaze would; moreover, the mending of imperfectly glazed pieces before firing is rendered almost impossible for the same reason. These points are of the utmost importance in practice, for, while greater care must be taken in sorting the bisque ware before dipping, as well as in the operations of dipping and placing, the proportion of defective pieces may still be too great to be borne. That, at all events, is the past experience of the potters who have worked with leadless glazes; and I feel assured that no firm of pottery manufacturers in this country is prepared to abandon leaded glazes for all their ordinary earthenware at the present time, and face the consequences. I cannot but consider that in this matter Profs. Thorpe and Oliver have been misled by the natural enthusiasm of those who have recently produced leadless glazes, and in their desire to put an end to the evils of lead-poisoning they have over-stated the

present value of leadless glazes to the trade at large. The time is not yet ripe for the drastic change proposed in their first recommendation.

Their third conclusion, "that the use of 'raw' lead, *i.e.* 'unfritted' lead, as an ingredient of potters' glazes or colours, should be absolutely prohibited," is not one whit too strong. The experience of pottery manufacturers in this country and on the continent proves that such a course is possible in every section of the trade. Between the bisilicate of lead containing 65 per cent. of lead monoxide, used at Rörstrand (report, p. 20) and at Dresden (report, p. 25), and proved in the experience of those works to have abolished lead-poisoning, and the compound silicate discovered by Prof. Thorpe (see report, p. 32) containing 22 per cent. of lead-oxide, and stated to be insoluble in dilute acids, and therefore non-injurious, there would seem to be ample margin for all the potter's requirements. According to the evidence contained in the report, such compounds have been used for years, or might be used, without producing lead poisoning in those who work with them. Were the use of such of these compounds as are found to best answer the practical requirements of the various trades, made compulsory on every potter in this country, and the Factory Inspectors empowered to take samples from the dipping-tubs for examination in the Government Laboratory, the axe would indeed be laid to the root of this evil.

The report is to be commended to the careful consideration of every one interested in a great industry. The facts stated in it, speaking generally, admit of little or no dispute. From a careful consideration of its pages, one gathers the encouraging conviction that it contains information which will enable the question to be fairly and satisfactorily dealt with from the point of view of workman, manufacturer, and Home Office alike. Its second and third recommendations, worked in conjunction with the monthly medical examination of *all* workers, of whatever sex or age, who come in contact with any form of lead compound, and with the adequate protective provisions as regards ventilation, clothing, and cleanliness, now in force at all pottery works in this country, would put an end, within a reasonable time, to the gross evils of plumbism. It is to be hoped that the pottery manufacturers will rise to the situation, and show their willingness to adopt such of the recommendations contained in the report as are of practical value.[1] The existing state of things, at all events, cannot be allowed to continue.

W. BURTON.

## *MECHANICAL ENGINEERING IN WARSHIPS.*

THE address delivered at the Institution of Mechanical Engineers on Thursday last, by the President, Sir William H. White, K.C.B., F.R.S., was a valuable statement of the part which mechanical engineering has played in the growth of our shipbuilding industry and the development of our mercantile marine during the past forty years. Mechanical engineering has intimate relations with all other branches of engineering, but with none has it been more closely associated than with shipbuilding in recent times; and in his address Sir William White indicated the directions in which the construction and working of ships have been influenced by it. He showed how the development of mechanical appliances for the equipment and working of ships during the last forty years is no less remarkable than the advance in the machinery used for shipbuilding. Nearly all steamships are now fitted with mechanical steering gear, mostly steam, in some instances hydraulic, and in a few recent ships electrical. The same motive powers are now used for working anchors and cables in steamships. Artificial ventilation is now very largely employed in many classes of ships, and especially in warships; electric lighting is becoming the rule; mechanical power is universally employed for pumping purposes in steamships; remarkable progress has been made in appliances for lifting coal and cargoes; and refrigerating machinery has led to the development of a new branch of the shipping industry, as well as added to the health and comfort of all who travel by sea. The advances in these and other directions were sketched by Sir William White, but the limitations of space prevent the publication of his address in full. The last section dealt with mechanical engineering in warships, and is here reprinted.

[1] The pottery manufacturers have already taken action in the direction indicated.

### *Mechanical Engineering in Warships.*

The auxiliary machinery of warships necessarily has much in common with the corresponding machinery in merchant ships. There are, however, many special requirements arising from their armament and equipment as fighting machines, and hence it happens that in warships the applications of mechanical power reach their fullest development. Modern warships are sometimes styled "boxes of machinery," and the description is not inapt. The tendency is, in fact, to multiply machines, and to minimise manual labour to an extent which is not universally approved. On the other hand, with modern armaments and equipment, an extensive use of mechanical power is inevitable, and the expenditure of fuel on auxiliary services grows greater in proportion to that devoted to propulsion.

Ten years ago in a first-class battleship of 12,000 h.p. (maximum) for the propelling machinery, there were fifty auxiliary engines capable of indicating in the aggregate about 5000 h.p. if they all worked simultaneously—which they did not, of course. To-day, a similar statement would show a growth in the auxiliary power as compared with the propelling.

The multiplication of auxiliary services makes very serious demands upon the coal-supply of warships. Even in harbour the expenditure of coal is large on lighting, distilling, ventilation, air-compression, drilling with the heavy guns, and other services. From 10 to 25 tons a day may thus be expended in a large battleship or cruiser of high speed. As warships cruise at low speeds and spend much time in harbour, it results that, taking the year through, fully as much coal is burnt for auxiliary services as for propulsion. Coal endurance being one of the most important factors in warship efficiency, facts such as these have tended to cause a doubt as to the wisdom of more widely extending mechanical appliances. It is pointed out that manual power with simple fittings, such as can be readily replaced if damaged in action, can compete with mechanical appliances in many directions; and that it is better to have larger crews in fighting ships, so as to provide a margin for inevitable casualties, than to use the alternative of labour-saving machines liable to derangement or injury and not easily repaired in action. The practical solution of the problem clearly lies in the due proportion being found between manual and mechanical appliances.

Gun construction in its modern form is largely dependent upon mechanical engineering. Your past-Presidents, Lord Armstrong and the late Sir Joseph Whitworth, were famous as mechanical engineers before they undertook the design and manufacture of guns. In this Address, however, the story of progress from the smooth-bore cast-iron 68-pr., weighing 95 cwts., to the 110-ton breech-loading rifled gun, firing 1800-lb. projectiles, can find no place. Nor can more than a brief glance be taken at the interesting work done by the mechanical engineer in regard to appliances for mounting, working, and loading modern guns, supplying the ammunition, and securing rapidity and accuracy of fire with a minimum of labour.

Anyone who will study the breech mechanism and mounting of a hand-worked quick-firing gun will discover a triumph of mechanical engineering over a very special and difficult problem. Take, for example, a 6-inch quick-firing gun of the latest naval pattern. The gun weighs about 7 tons, fires 100-lb. projectiles, with a muzzle velocity of nearly 2800 feet per second, and an energy of 5370 foot-tons, corresponding to a penetration of 22 inches of wrought iron. Its breech mechanism is so devised that four or five aimed shots can be fired per minute. Its mounting is so arranged that the gun can be easily trained, elevated or depressed by one man. The great energy of recoil is perfectly controlled, and the crew numbers only four or five men. If such a gun is compared with the 68-pr. smooth-bore muzzle loader, mounted on a wood truck carriage with rude arrangements for elevating, and still ruder for training and controlling recoil, one has a striking illustration of the progress made in forty years with hand-worked guns.

When one passes to heavier guns worked by mechanical power, a still greater contrast appears. The 110-ton gun of 16¼ inches calibre has charges of 960 lbs. of powder and 1800-lb. projectiles. Fired with a velocity of 2100 feet per second, three projectiles have an energy of 54,000 foot-tons with an estimated penetration of 37 inches of wrought iron. Obviously, manual power alone was unequal to working such guns. The mechanical engineer has devised suitable machinery which enables pairs of guns, mounted in a thickly armoured turret, to be

loaded, trained, elevated, and depressed with ease and comparative rapidity under the guidance of a few men. Mr. George Rendel was one of the first, as well as one of the most successful, workers in the design of mechanical appliances for working heavy guns by hydraulic power. Messrs. Armstrong have from the first taken a leading position in this class of work. Messrs. Whitworth, and, in more recent times, Messrs. Vickers, have also undertaken it on a large scale. Hydraulic power finds most favour in the Royal Navy. Abroad, electrical power is now extensively used. Pneumatic power has been employed in a few cases.

Improvements in gun-design and in explosives have resulted in an increased ratio of power to weight in the latest types of guns. As a result, in the latest completed battleships, guns of 12-inch calibre, weighing 46 tons, firing 850-lb. projectiles, with muzzle velocities of about 2400 feet per second, and energies of 33,000 foot-tons have been used instead of the 67-ton and 110-ton guns of early date. These reduced weights of charges and projectiles are more easily handled; and this fact, together with certain changes in the system of mounting, have enabled many of the operations of loading and working the guns to be performed by manual power as well as by hydraulic power. This duplication is obviously advantageous, and reduces greatly the risk of heavy guns being put out of action. There was a time when a return to guns of still smaller dimensions, capable of being worked exclusively by hand-power, was strongly advocated. It was urged that it was unwise to depend at all on mechanical power, because it might fail at a critical moment. Such arguments are now but little heard. Experience does not demonstrate that any serious risk of "breakdown" need be feared in mechanical appliances. Moreover, the advocates of manual power overlooked the fact that, supposing that system had been adopted, there must still remain in all modern mountings and breech mechanisms many comparatively delicate parts, perhaps more liable to injury or derangement than the appliances which were condemned.

Steady improvement has been made in heavy gun mountings and in rapidity of fire. For example, with 12-inch guns from two and a half to three minutes were formerly considered to be a reasonable interval between successive rounds; now that interval has been brought below one minute, when pairs of guns are loaded and fired. Loading has also been made possible with the guns in any position, whereas formerly the guns were brought to fixed hoists, and to a definite angle of elevation for loading. It is most interesting to watch the working of these heavy guns, by means of mechanisms controlled by a few men. All the operations are performed with rapidity and precision, from the moment projectiles and charges are moved from their stowing positions in shell rooms and magazines situated deep down in the holds, up to the time when they are rammed home in the gun, the breech closed and the gun made ready for firing. Then one sees the captain of the barbette or turret training or changing the elevation of the gun up to the instant when he fires by electricity, and the huge projectile is discharged.

Passing from guns to torpedoes, one finds a fresh example of the important work done by mechanical engineers. The inventor of the automobile torpedo, Mr. Whitehead, is an eminent member of the profession. The torpedo itself is a beautiful example of mechanical engineering. All the machinery connected with air compression and storage, all the arrangements for ejecting above or below water, involve skilful mechanical design. Nor is this all. From the introduction of the torpedo has sprung the necessity for special structural and defensive arrangements in warships, as well as the construction of the swift torpedo flotilla-boats, destroyers, gunboats and depot ships, whose performances are not merely remarkable, but suggestive of possibilities in regard to steam navigation at high speeds.

The smaller classes of boats using the locomotive torpedo have to be carried by warships. They weigh, fully equipped, 18 to 20 tons, or about three times as much as the heaviest load ordinarily dealt with in merchant ships by their own lifting gear. This has involved the design of special lifting appliances for warships. After long experience in the Royal Navy, the most suitable arrangement has been found to be a strong steel derrick carried by the mast, with powerful steam or hydraulic hoists working tackles which lift the boats and top the derrick. Winches or capstans are also used in some instances for swinging the derricks. Admiralty specifications require that the lifting gear shall be capable of dealing with a load of about 18 tons lifted by a single wire rope, as well as with a load of 9 tons raised 30 feet per minute. In one ship, the *Vulcan*, built as a torpedo depot ship and boat carrier, instead of derricks two powerful hydraulic cranes are fitted. She carries six steel torpedo boats, 60 feet long and of 16 knots speed, besides sixteen other boats, some of large size. The total weight of these boats is 150 tons, and they are placed 27 feet above water. The two cranes and their gear weigh 140 tons; the tops of the cranes are 55 feet above water. It required careful designing to meet such exceptional conditions satisfactorily and to produce a stable and seaworthy ship. She has now been many years on service and has a good reputation.

Besides these special boat-lifting appliances, warships commonly have special coal-hoists, transporters and other gear for the purpose of accelerating the taking of coal on board. Rapidity in coaling must be of great importance in time of war, and keen competition between ships in the various squadrons as to the rates attained have led to great improvements in details of gear, as well as to remarkably rapid coaling becoming the rule in the Royal Navy. Recently, at Gibraltar, the *Majestic* took on board 1070 tons of coal in 6 hours and 10 minutes—a very fine performance.

All the larger ships in the Royal Navy have engineers' workshops fitted with a considerable number of machine-tools, driven by power, and of sufficient size to deal with ordinary repairs. The *Vulcan* is a special vessel in this sense also, as she has an exceptionally well-equipped workshop, a small foundry and a hydraulic press for forgings. For repairs of the boats she carries, or for those of torpedo boats and destroyers in company, or for certain repairs to ships of the fleet to which she is attached, the *Vulcan* has been found most useful. Besides being a floating factory and a boat carrier, she has a large torpedo and mining equipment, an electrical laboratory, and serves as a school of instruction for mining and torpedo work. In addition, she is a swift cruiser, with a fair armament and well protected. As an armed ship, she represents the fullest application of mechanical appliances afloat. Her construction was commenced in 1887. Other navies have since imitated her.

Another *Vulcan* was fitted up as a floating factory to serve with the American fleet during the recent war. She was originally a merchant steamer, but is said to have proved of great service. Naval opinion seems to favour the use of vessels of this class with fleets. It is held, moreover, that no modern fleet can be considered to be complete unless the fighting ships are supplemented by ships specially equipped for distilling and storing fresh water, or carrying coals, ammunition and reserve stores.

## SATURN'S NEW SATELLITE.

IN *Harvard College Observatory Circular*, No. 43, just received, Prof. E. C. Pickering gives the following detailed account of the discovery and observations of the new satellite of Saturn:—

Nearly all of the astronomical discoveries made by the aid of photography have related to the fixed stars. In the study of the members of the solar system, the results obtained by the eye are generally better than those derived from a photograph. For many years it has been supposed that photography might be used for the discovery of new satellites, and in April 1888 a careful study of the vicinity of the outer planets was made by Prof. William H. Pickering. Photographs were taken with the 13-inch Boyden telescope, with exposures of about one hour, and images were obtained of all the satellites of Saturn then known except Mimas, whose light is obscured by that of its primary. It was then shown that Saturn probably had no satellite, as yet undiscovered, revolving in an orbit outside of that of Enceladus, unless it was more than a magnitude fainter than Hyperion (Forty-third Report Harv. Coll. Obs., p. 8).

In planning the Bruce photographic telescope, a search for distant and faint satellites was regarded as an important part of its work, and accordingly plates for this purpose were taken at Arequipa by Dr. Stewart. A careful examination of these plates has been made by Prof. William H. Pickering, and by superposing two of them, A 3228 and A 3233, taken August 16 and 18, 1898, with exposures of 120 m., a faint object was found which appeared in different positions on the two plates. The same object is shown on two other plates A 3227 and A 3230, taken

on August 16 and 17, 1898, with exposures of 60m. and 122m. respectively.

The position is nearly the same on the two plates taken on August 16, but on August 17 it followed this position 33″, and was south 19′, while on August 18 it followed 72′, south 43″. Its motion was direct, and less than that of Saturn, though nearly in the same direction. It cannot, therefore, be an asteroid, but must either be a satellite of Saturn or a more distant outside planet. The proximity of Saturn renders the first supposition much more probable. On August 17 the position angle from Saturn was 106°, and the distance 1480″. Assuming that it was at elongation, and that its orbit is circular, its period would be 400 days, or five times that of Japetus. It was at first identified with a very faint object found on plates taken in 1897, and the period of seventeen months was derived from them. This supposition has not been confirmed.

Measurements of the positions of the images give additional material for determining the form of the orbit. The method of measurement is that described in the *Annals*, vol. xxvi. p. 236. The uncorrected positions of the four images referred to the first plate of August 16 as an origin, are for $x$, 0″·0, +1″·2, +33″·6, and +71″·8; for $y$, 0″·0, −1″·7, −19″·8, and −42″·1; the corresponding Greenwich mean times are 12h. 16m., 14h. 18m., 12h. 56m., and 13h. 12m. Correcting for the motion of Saturn, the relative motion with reference to that body is in $x$, 0″·0, −2″·4, −10″·7, and −22″·0; in $y$, 0″·0, +0″·1, +2″·4, and +2″·9. It appears from this that the apparent motion is about 10″·4 a day, at a distance of 1480″. A computation shows that if the orbit is circular, the period must be either 4200 or 490 days, according as the satellite is near conjunction or elongation. These values may be greatly altered if the orbit is elliptical. Since the interval of time between the first and last photographs on which the satellite appears is only two days, it is impossible to predict its position with accuracy. It is probable that its position angle from Saturn now lies between 280° and 290°, and its distance between 20′ and 30′. These uncertainties will probably be greatly diminished from measures of plates of Saturn taken in Arequipa on September 15, 16, and 17, 1898, which for some unexplained reason have not yet been received in Cambridge.

The direction of the motion, which is nearly towards Saturn, shows that the apparent orbit is a very elongated ellipse, and that it lies nearly in the plane of the ecliptic. Prof. Asaph Hall has pointed out that this is to be expected in a body so distant from Saturn. The attraction of the latter only slightly exceeds that of the sun. Hyperion appears as a conspicuous object on all four of the plates, and the new satellite appears about a magnitude and a half fainter on each. The approximate magnitude is therefore about 15·5. As seen from Saturn, it would appear as a faint star of about the sixth magnitude. Assuming that its reflecting power is the same as that of Titan, its diameter would be about two hundred miles. It will, therefore, be noticed that while it is probably the faintest body yet found in the solar system, it is also the largest discovered since the inner satellites of Uranus in 1851. The last discovery of a satellite of Saturn was made in September 1848 by Prof. William C. Bond, then director of this Observatory, and his son, Prof. George P. Bond. The satellite Hyperion was seen by the son on September 16 and 18, but its true character was first recognised on September 19, when its position was measured by both father and son (see *Annals*, ii. p. 12). Soon afterwards it was discovered independently by Lassell, at Liverpool.

Prof. William H. Pickering, as the discoverer, suggests that the name Phœbe, a sister of Saturn, be given to the new satellite. Three of the satellites—Tethys, Dione, and Rhea—have already been named for Saturn's sisters, and two, Hyperion and Japetus, for his brothers.

## *UNIVERSITY AND EDUCATIONAL INTELLIGENCE.*

Cambridge.—The following are the speeches delivered on April 27 by the Public Orator, Dr. Sandys, in presenting (1) Prof. Sir William Turner and (2) the Rev. Prof. Wiltshire, for the honorary degree of Doctor in Science:—

(1) Virum regni totius medicorum concilio praepositum, virum honoribus academicis plurimis cumulatum, etiam noster Senatus titulo suo decorare anno proximo decrevit. Inter Lancastrienses natus, inter Londinienses educatus, inter Edinenses, medicinae in schola celeberrima, quam tot coloniae Britannicae studiorum medicorum quasi μητρόπολιν venerantur, anatomiae scientiam per annos plus quam triginta praeclare professus, non modo Universitati suae aedificiis novis instruendae operam insignem dedit, sed etiam studiorum suorum actis per seriem edendis iamdudum maxima cum laude praefuit. Idem, rerum naturae spoliis olim in Britanniam feliciter reportatis, Australasiae praesertim anthropologiam opere in magno accuratissime expositam luculenter illustravit. Nuper societatis Britannicae scientiarum finibus proferendis praeses in annum proximum designatus, ab eadem disputationibus de anthropologiae scientia etiam inter Canadenses habendis haud ita pridem praepositus, hominum omnium plausus propterea praesertim meritus est, quod simiarum superbiam recentem repressit et generis humani dignitatem veterem denuo vindicavit.

Duco ad vos generis humani vindicem, equitem insignem, anatomiae professorem illustrem, Willelmum Turner.

(2) Unus ex alumnis nostris, societatis geologicae, astronomicae, Linnaeanae socius, idcirco praesertim inter peritos laudatur, quod palaeontographicae societatis in usum, palaeontologiae studiosorum ad fructum, aevi prioris monumenta a rerum natura in saxis impressa, non sine summo ingenio et labore illustrata, per annos plurimos litterarum monumentis mandaverit. Idem Universitatem nostram beneficio singulari ad sese devinxit, quod non modo bibliothecam suam, sed etiam vitae antiquae relliquias veteres in saxis conservatas et saxorum inter se diversorum exempla quam plurima, nuper nobis in perpetuum donavit. Illa vero exempla omnia, olim inter Londinienses in Collegio Regali professor, docendi praesertim in commodum collegerat, cum Horatio (ut videtur) arbitratus "demissa per aurem quam quae sunt oculis subiecta" animum segnius excitare. Etiam ipsa fama liberalitatis tantae nuper inter nosmet ipsos inter rerum naturae praesertim studiosos animum gratum excitavit. Quanto magis iuvat Universitatem totam liberalitatis tantae auctorem ipsum hodie oculis suis redditum et auspiciis optimis praesentem contemplari. Qui prioris aevi tot exempla nobis donavit, ipse nostro in saeculo munificentiae in Universitatem nostram ab aliis imitandum praebuit exemplum.

Praesento vobis geologiae professorem emeritum, virum de rerum naturae studiis praeclare meritum, Thomam Wiltshire.

Prof. A. Cornu, of the École Polytechnique of Paris, has been appointed Rede Lecturer for the present year. The lecture will be delivered in the Senate House on June 1, as a part of the proceedings relating to the jubilee of Sir G. G. Stokes. On the same evening, a conversazione will be held in the Fitzwilliam Museum. Next day an address from the University and a commemorative gold medal will be presented to the veteran Lucasian professor. The guests of the University will be received by the Chancellor, and certain honorary degrees will be conferred. A garden-party at Pembroke College, and a State dinner in the evening, will close the festivities.

Prof. Macalister announces three lectures of an historical character, on eponymous structures in human anatomy, on May 9, 13, and 16.

University tables are vacant at the Naples and the Plymouth Zoological Stations. Applications are to be sent to Prof. Newton by June 1.

The *Times* makes the following announcement:—"We understand that Mr. Passmore Edwards has intimated his intention of giving 10,000*l*. upon trust to equip a school and building for the teaching of economics and commercial science in the New London University. The Trustees, who are to carry out the trust and offer the building when ready to the new University Senate, are the Bishop of London, Mr. Sidney Webb, and Mr. Haldane, Q.C., M.P. The work of the London School of Economics will probably be continued there. Further endowments will, of course, be wanted for chairs of banking, commercial history and geography, commercial law, insurance and other special subjects, and this munificent gift by Mr. Passmore Edwards should encourage other wealthy Londoners to imitate his generosity."

## SOCIETIES AND ACADEMIES.

### LONDON.

**Royal Society**, April 20.—"On Intestinal Absorption, especially on the Absorption of Serum, Peptone, and Glucose." By E. Waymouth Reid, F.R.S., Professor of Physiology in University College, Dundee, St. Andrews University, N.B.

The experiments detailed in the full paper deal with the absorption from the intestine, of the animal's own serum, and of solutions of glucose and peptone. The method employed has been that introduced by Leubuscher, in which two loops of intestine are simultaneously employed, the one the experimental, and the other the control, loop.

The conclusions arrived at are as follows :—

(1) A physiological activity of the intestinal epithelium in the act of absorption is demonstrated by—

(*a*) The absorption by an animal of its own serum (or even plasma) under conditions in which filtration into blood capillaries or lacteals, osmosis and adsorption are excluded.

(*b*) By the cessation or diminution of the absorption of serum when the epithelium is removed, injured or poisoned, in spite of the fact that removal, at any rate, must increase the facilities for osmosis and filtration.

(2) The activity of the cells is characterised by a slower uptake of the organic solids of the serum than of the water, and a rather quicker uptake of the salts than of the water. The relations to one another of the absorptions of these various constituents is variable in different regions of the intestinal canal (upper ileum, lower ileum, and colon).

(3) No evidence can be obtained of specific absorptive fibres in the mesenteric nerves.

(4) The state of nutrition of the cells is the main factor in their activity, and this is intimately associated with the blood supply.

(5) In reduction of the rate of absorption, without detachment of epithelium, the absorption of the various constituents of serum is reduced in the proportion in which they exist in the original fluid.

(6) The activity of the cells may be raised by stimulation with weak alcohol, without evidence of concomitant increase of blood supply.

(7) The bile has no stimulant action on the cells.

(8) The cells exhibit an orienting action upon salts in solution (sodic chloride especially). In a loop of gut with injured cells, sodic chloride enters the lumen from the blood at a time when it is being actively absorbed from a normal control loop in the same animal. (This fact was first noted by O. Cohnheim.)

(9) The absorption of water from solutions introduced into the gut is dependent upon two factors :—

(*a*) The physical relation of the osmotic pressure of the solution in the gut to the osmotic pressure of the blood plasma.

(*b*) The physiological regulation of the difference of osmotic pressure by the orienting mechanism of the cells.

(10) The chief factor in the absorption of peptone is an assimilation (or adsorption) by the cells, while in the absorption of glucose, diffusion, variable by the permeability of the cells (and so, probably, related to their physiological condition) is the main factor.

(11) By removal of the epithelium, the normal ratio of peptone to glucose absorption is upset, and the value tends to approach that of diffusion of these substances through parchment paper into serum.

(12) Absorption in the lower ileum is greater for the organic solids of serum, and less for peptone and glucose than in the upper ileum. The relative absorption of water in the upper and lower ileum is variable.

(13) The relative impermeability of the lower ileum to glucose disappears with removal of the epithelium.

(14) Absorption in the colon is for all constituents of serum, and for peptone and glucose far less per unit of measured surface than in the middle region of the ileum.

(15) The normal relative excess of salt absorption from serum over water absorption, observed throughout the intestine, is most marked in the colon, and more marked in the lower than in the upper ileum.

(16) Finally, it is suggested that the cell activity which causes serum to pass over to the blood is of the same nature as that involved in the orienting action of the cells upon salts in solution.

**Zoological Society**, April 18.—Prof. G. B. Howes, F.R.S., Vice-President, in the chair.—Mr. C. W. Andrews read a paper on the osteology of one of the great extinct birds of Patagonia, *Phororhacos inflatus*. He described in detail the structure of the skull and skeleton, and compared them with various recent forms of birds. The evidence as to the affinity of this type was somewhat conflicting, but on the whole pointed to a relationship with the *Gruiformes*, as had been previously suggested by the author. It seemed probable that the aberrent *Cariama* was the nearest living representative of *Phororhacos*, being related to it somewhat in the same fashion as the small modern Armadillos are to the great extinct forms such as *Glyptodon* and *Panochthus*.—A communication was read from Mr. P. W. Bassett-Smith, entitled "A systematic description of the parasitic Copepoda found on fishes." It contained a summary of the literature on the subject, and an enumeration of the known species of these parasites and lists of their synonyms. A new family (*Philichthydidae*) was introduced, to embrace the forms which are found in the mucous canals and sinuses of fishes, and a new genus (*Oralien*) was proposed for the reception of *Chondracanthus triglae* (Blainv.).—Mr. W. E. de Winton read a paper on the African species of *Canidae*. The author, from an examination of a series of specimens lately received from Africa, had come to the conclusion that the known species of *Canidae* of that continent were fourteen in number. He pointed out that the numerous supposed new species of jackals that had recently been described were mostly varieties of well-known forms, and that he was of opinion that only four species of jackals were found in Africa, viz. *Canis anthus*, *C. variegatus*, *C. mesomelas*, and *C. adustus*.—A communication from Dr. H. von Ihering, on the Ornis of the State of São Paulo, Brazil, was read. It embraced the conclusions arrived at, from observations made by the author during the last six years, regarding the distribution of birds in that State, in which he recognised elements of three different faunas—namely, the northern and southern divisions of the South-east Brazilian fauna, and the Central Brazilian or Pampas fauna of the interior.—A communication from Mr. G. A. Boulenger, F.R.S., contained the description of a new lizard from Ecuador under the name *Ameiva leucostigma*.—A communication was read from the Rev. O. Pickard-Cambridge containing descriptions of twelve new species of exotic Araneidea.

### MANCHESTER.

**Literary and Philosophical Society**, April 11.—Mr. J. Cosmo Melvill, President, in the chair.—Mr. John Watson read a paper entitled "On *Calinaga*, the single genus of an aberrant sub-family of butterflies." He first referred to the species known to science, and to the uncertainty as to where this curious butterfly should be placed in the classification of insects. It was pointed out that, besides the evidence of its geographical distribution, the structure of the feet pointed to the probability of its being a very ancient form. The basal cell shows a close affinity to the *Glacialis* section of *Parnassius*, and the general tendency of the structure of *Calinaga* was towards its being an offshoot—an early offshoot—of the Lepidopterous phylum from which the Papilioni-Pieri-Nymphalid stock originated. A paper on a biological aspect of cancer was read by Mr. F. J. Faraday. Cancer has been defined as epithelial proliferation, with an invading tendency. The author suggested that it was a case of arrested development, at what might be termed the cryptogamic as distinct from the phanerogamic stage. He pointed out that changes in the environment, noticeably a deficient supply of free oxygen and sunlight, had a remarkable influence in arresting organised differentiation and favouring the development of cryptogamic parasitism; and cited the attenuation and fermentation experiments of Pasteur and his successors. The "travelling cell" in cancer could only be described as a pathogenic micro-coccus evolved from normal epithelial cells. From analogy, the author inferred that deficient oxygenation of the blood generally, or deficient local blood-irrigation through local causes or interruptious, might account for the cancerous proliferation.

### PARIS.

**Academy of Sciences**, April 24.—M. van Tieghem in the chair.—The President announced to the Academy the death of M. Charles Friedel.—On surfaces of constant positive curvature, by M. Gaston Darboux.—Electrical registration of the valvular movements which determine the opening and closing of the orifices of the heart, by M. A. Chauveau. Diagrams obtained

by the apparatus are given, showing the curves of the tricuspid, mitral and aortic valves.—New observations of the planet EL (Coggia, March 31, 1899), made at the Observatory of Marseilles with the 26 cm. equatorial, by M. E. Stéphan.—Observations of the new Coggia planet (EL), made at the Observatory of Algiers with the 31·6 cm. equatorial, by M. Rambaud.—On the sterilisation of potable waters by ozone on the industrial scale, by MM. Marmier and Abraham. The apparatus was set up at Lille. After the water had passed through the ozonising column, all saprophytic and pathogenic organisms were destroyed with the exception of some spores of *Bacillus subtilis*; this organism also offering considerable resistance to all the usual methods of sterilisation.—On furfuryl alcohol, by M. G. André. Specimens of this alcohol prepared by different methods for calorimetric determinations differed considerably in purity, the method of Wissel and Tollens being the only one yielding a pure substance.—Osazones from oxycelluloses, by M. Léo Vignon. Cotton wool was oxidised in various ways to oxycelluloses, and these heated with phenylhydrazine in acetic acid solution. The osazones formed were not constant in composition.—On the sugar of maize stems, by MM. C. Istrati and G. Œttinger. Measurements of the reducing power before and after inversion of the juice from the stems of sixteen varieties of maize.—Remarks on a preceding communication "On the pathogenic agent of hydrophobia," by M. E. Puscariu. The amylaceous formations observed in the central nervous system of animals who died from hydrophobia have been found in cases of general paralysis, abscess of the brain and in diphtheric paralysis. Hence the view previously put forward, that these formations are of parasitic origin and peculiar to hydrophobia, is erroneous.—On the reducing power of the tissues: the blood, by M. Henri Hélier.—On a ratio existing between intraorganic oxidations and the production of kinetic energy in the organism, by M. Alexandre Poehl.—The microbes of flowers, by M. Domingos Freire. Numerous species of organisms have been found in flowers, including the pathogenic *Bacillus pyocyaneus*.—On the wines obtained by the preliminary heating of the vintage, by M. A. Rosenstiehl. The preliminary sterilisation of the must by heating and the subsequent introduction of suitable yeasts, in all the instances tried, gave a wine superior to that obtained by the traditional methods.—The specific characters of the fungus of *Pityriasis versicolor*, by M. Paul Vuillemin.—Researches on the mineral elements, especially iron, in the human fœtus, by M. L. Hugounenq.—The formation of the egg in *Myriothela* and *Tubularia*, by M. Alphonse Labbé.—Tangential increase of the pericycle, by M. Henri Devaux.—Discussion of barometric observations, by M. A. Poincaré.

## DIARY OF SOCIETIES.

*THURSDAY*, MAY 4.

ROYAL SOCIETY, at 4.30.—On the Chemical Classification of the Stars: Sir Norman Lockyer, F.R.S.—Demonstration of Vermiform Nuclei in the Fertilised Embryo Sac of *Lilium martagon*: Miss E. Sargant.—*Onygena equina* (Willd.): a Horn-destroying Fungus: Prof. Marshall Ward, F.R.S.—Impact with a Liquid Surface studied by the Aid of Instantaneous Photography. Paper II.: Prof. Worthington, F.R.S., and R. C. Cole.—The External Features in the Development of *Lepidosiren paradoxa* (Fitz.): J. G. Kerr.—An Observation on Inheritance in Parthenogenesis: Dr. E. Warren.—The Thermal Expansion of Pure Nickel and Cobalt: A. E. Tutton.

LINNEAN SOCIETY, at 8.—The Position of Anomalurus as indicated by its Myology: F. G. Parsons.—On *Notheia anomala*, Harv. et Bail.: Miss Ethel S. Barton.—On Variation in the Desmidiæ: G. S. West.

CHEMICAL SOCIETY, at 8.—On the Combustion of Carbon Disulphide: H. B. Dixon and F. J. Russell.—The Action of Nitric Oxide on Nitrogen Peroxide: H. B. Dixon and J. D. Peterkin.—On the Mode of Burning of Carbon: H. B. Dixon.—Crystalline Glycollic Aldehyde: Henry J. Horstman Fenton and Henry Jackson.—On the Blue Salt of Fehling's Solution and other Cupro-tartrates: Orme Masson and B. D. Steele.—The Preparation of Acid Phenolic Salts of Dibasic Acids: Dr. S. B. Schryver.—The Maximum Pressure of Naphthalene Vapour: R. W. Allen.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—Electric Locomotives in Practice and Tractive Resistance in Tunnels, with Notes on Electric Locomotive Design: G. V. McMahon.

*FRIDAY*, MAY 5.

ROYAL INSTITUTION, at 9.—Pictures produced on Photographic Plates in the Dark: Dr. W. J. Russell, F.R.S.

GEOLOGISTS' ASSOCIATION, at 8.—The Drainage of Cuestas: Prof. W. M. Davis.

*SATURDAY*, MAY 6.

GEOLOGISTS' ASSOCIATION.—Excursion to the Thame District. Director: A. M. Davies. Leave Paddington at 9.50.

*MONDAY*, MAY 8.

SOCIETY OF ARTS, at 8.—Leather Manufacture: Prof. H. R. Proctor.

ROYAL GEOGRAPHICAL SOCIETY, at 8.30.—Explorations in the Bolivian Andes: Sir Martin Conway.

*TUESDAY*, MAY 9.

ROYAL INSTITUTION, at 3.—Electric Eddy-Currents: Prof. S. P. Thompson, F.R.S.

ANTHROPOLOGICAL INSTITUTE, at 8.30.—Ethnographical Notes on the Fang: Dr. Albert L. Bennett.

ROYAL PHOTOGRAPHIC SOCIETY, at 8.—The Photography of Colour: E. Sanger Shepherd.

*WEDNESDAY*, MAY 10.

SOCIETY OF ARTS, at 8.—Fruit-Growing in Kent: George Bunyard.

GEOLOGICAL SOCIETY, at 8.—The Geology of the Davos District: A. Vaughan Jennings.—Contributions to the Geological Study of County Waterford: the Lower Palæozoic Bedded Rocks of the Coast: F. R. Cowper Reed.

*THURSDAY*, MAY 11.

MATHEMATICAL SOCIETY, at 8.—The Zeroes of a Spherical Harmonic $P_n^m(\mu)$ considered as a Function of $n$: H. M. Macdonald.

*FRIDAY*, MAY 12.

ROYAL INSTITUTION, at 9.—Magnetic Perturbations of the Spectral Lines: Prof. Thomas Preston, F.R.S.

ROYAL ASTRONOMICAL SOCIETY, at 8.

MALACOLOGICAL SOCIETY, at 8.

## BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—City and Guilds of London Institute, Report to the Governors, March 1899 (London).—Engine-Room Practice: J. G. Liversidge (Griffin).—Manual of Library Cataloguing: J. H. Quinn (Library Supply Company).—The Philosophy of Memory: Dr. A. T. Smith (Louisville, Morton).—The Flora of Cheshire. Lord de Tabley (Longmans).—Outlines of Zoology: Prof. J. A. Thomson, 3rd edition (Pentland).—The Phenomena of Nature: J. Walker, Part 2 (Sonnenschein).—Essai Critique sur l'Hypothèse des Atoms: Prof. A. Hannequin, deux édition (Paris, Alcan).—Graduated Test Papers in Elementary Mathematics: W. J. Wood (Macmillan).—Annual Report of the Smithsonian Institution, 1897 (Washington).—Milk: Dr. C. M. Aikman, 2nd edition (Black).

PAMPHLETS.—Some Insects Injurious to Garden and Orchard Crops (Washington).—Geological Society of Washington, Presidential Address: A. Hague (Washington).—Return, Local Authorities (England, Wales, and Ireland), Technical Education (London).

SERIALS.—Indian Museum Notes, Vol. iv. No. 3 (Calcutta).—Transactions of the Institution of Engineers and Shipbuilders in Scotland, April (Glasgow).—American Naturalist, April (Boston).—Bulletin of the American Mathematical Society, April (New York).—Bulletin de la Société Impériale des Naturalistes de Moscou, 1898, Nos. 2 and 3 (Moscou).

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THURSDAY, MAY 11, 1899.

## *THE NATIONAL PHYSICAL LABORATORY.*

THE following Scheme for the government of the National Physical Laboratory has been drawn up by the Royal Society with the approval of Her Majesty's Treasury, and steps are being taken to give effect to the Scheme at as early a date as practicable. The Government has promised to ask Parliament for a grant of 12,000*l*. for buildings, and an annual grant of 4000*l*., and will also facilitate the erection of the buildings in the Deer Park at Kew. The resources of the Kew Committee of the Royal Society and the buildings used by them will also be handed over to the new Institution.

The grant will not be available until voted by Parliament, and the first grant will be 5000*l*. for buildings and 2000*l*. in respect of the first half-year. The Treasury have, however, approved of the immediate nomination of the new governing body, and have authorised any preparations for the work of the Laboratory, which can be undertaken without expenditure, previous to the sanctioning of the anticipated grants by Parliament.

The President and Council of the Royal Society have accordingly appointed the Executive Committee, in accordance with the provisions of the Scheme, with a view to preliminary arrangements being set on foot as soon as possible; and will shortly proceed to complete the constitution of the General Board. The representatives nominated by the technical Institutions named in the Scheme to serve on the General Board are as follows:—

| | |
|---|---|
| Mr. W. H. Preece, F.R.S. ... ...<br>Sir J. Wolfe-Barry, F.R.S. ... ... | Institution of Civil Engineers. |
| Sir Wm. White, F.R.S. ... ...<br>Sir Edw. Carbutt, Bart. ... ... | Institution of Mechanical Engineers. |
| Mr. Alex. Siemens ... ... ...<br>Prof. Ayrton, F.R.S. ... ... ... | Institution of Electrical Engineers. |
| Sir Wm. Roberts-Austen, F.R.S.<br>Sir Fredk. Abel, F.R.S. ... ... | Iron and Steel Institute. |
| Mr. Geo. Beilby ... ... ... ...<br>Mr. Walter F. Reid ... ... ... | Society of Chemical Industry. |
| Sir Nathaniel Barnaby ... ... ...<br>Mr. J. T. Milton ... ... ... ... | Institution of Naval Architects. |

The President and Council of the Royal Society have appointed as Vice-Chairman of the General Board and of the Executive Committee:

Lord Rayleigh, F.R.S.

The following are the other members of the Executive Committee:

| | |
|---|---|
| Lord Lister, President of the Royal Society.<br>Mr. A. B. Kempe, Treasurer of the Royal Society.<br>Prof. A. W. Rücker, as Secretary of the Royal Society.<br>Sir Courtenay Boyle, K.C.B., Permanent Secretary of the Board of Trade. | *ex officio.* |
| Capt. W. de W. Abney, F.R.S. ... ...<br>Capt. E. W. Creak, F.R.S. ... ...<br>Prof. G. Carey Foster, F.R.S. ... ...<br>Mr. F. Galton, F.R.S. ... ... ...<br>Prof. J. Perry, F.R.S. ... ... ...<br>Gen. Sir R. Strachey, F.R.S. ... ... | from among the Members of the Kew Observatory Committee. |
| Sir John Wolfe-Barry, F.R.S. ... ...<br>Sir Edward Carbutt, Bart. ... ...<br>Mr. Alex. Siemens ... ... ...<br>Sir William Roberts-Austen, F.R.S. ...<br>Mr. G. Beilby ... ... ... ...<br>Sir Nathaniel Barnaby ... ... ... | from among those Members of the General Board nominated by the technical Societies named in the Scheme; and |
| Prof. R. B. Clifton, F.R.S.<br>Prof. O. Lodge, F.R.S. ... ... ...<br>Sir Andrew Noble, F.R.S. ... ...<br>Prof. A. Schuster, F.R.S. ... ...<br>Prof. J. J. Thomson, F.R.S. ... ...<br>Dr. Thorpe, F.R.S. ... ... ... | Nominated by the President and Council of the Royal Society. |

The Scheme of Organisation of the Laboratory is as follows:—

1. The name of the Institution shall be the National Physical Laboratory. The Kew Observatory shall be incorporated therewith.

2. The ultimate control of the Institution shall be vested in the President and Council of the Royal Society, who, in the exercise thereof, may from time to time issue such directions as they may think fit to the General Board and Executive Committee hereinafter described. The President of the Royal Society shall be the Chairman of the Governing Body as hereinafter defined. The income and all other property of the Institution shall be vested in the Royal Society for the purposes of the Institution.

3. For the present, and until otherwise ordered by the President and Council of the Royal Society, with the approval of H.M. Treasury, there shall be a Governing Body for the Institution, consisting of a General Board and an Executive Committee, the constitution and duties of which shall be as hereinafter defined. Provided always that the Permanent Secretary of H.M. Board of Trade shall be *ex officio* a member of the Governing Body, and that the choice of members of the Governing Body, or of any Committee thereof, shall not be confined to Fellows of the Royal Society.

4. The General Board shall consist of the President, Treasurer, and Secretaries of the Royal Society, the Vice-Chairman of the Board (appointed as defined below by the President and Council of the Royal Society), the Permanent Secretary of the Board of Trade, and of thirty-six ordinary members.

Twenty-four of the ordinary members shall be appointed by the President and Council of the Royal Society; of the remaining twelve ordinary members, two shall be nominated for appointment by the Council of each of the following Institutions, as being fitted to represent commercial interests in connection with the Laboratory:—

The Institution of Civil Engineers.
The Institution of Mechanical Engineers.
The Institution of Electrical Engineers.
The Iron and Steel Institute.
The Institution of Naval Architects.
The Society of Chemical Industry.

In the selection of ordinary members of the General Board care shall be taken that Scotland and Ireland are represented.

Any person not being already a member of the General Board who shall become a member of the Executive Committee, shall be a member of that Board during his tenure of office on the Executive Committee, but shall be regarded as an additional, and not as an ordinary member of the Board.

5. The Executive Committee shall consist of the President, Treasurer, and one of the Secretaries of the Royal Society; the Vice-Chairman of the Executive Committee (appointed as defined below); the Permanent Secretary of the Board of Trade; six persons appointed by the President and Council of the Royal Society from among those who are members of the Kew Observatory Committee at the time when the Kew Observatory is incorporated in the National Physical Laboratory (two of these six persons shall retire at the end of every two years, and vacancies occurring amongst them by retirement or otherwise shall not be filled up); and of twelve ordinary members.

The ordinary members shall be nominated by the

President and Council of the Royal Society, but one-half shall be chosen from among those members of the General Board who have been nominated as fitted to represent commercial interests on that Board.

Those members of the Executive Committee who are Fellows of the Royal Society, shall be appointed by the President and Council to be the Gassiot Committee of the Royal Society.

6. The Vice-Chairman of the General Board shall be appointed by the President and Council of the Royal Society, and shall also be Vice-Chairman of the Executive Committee. He shall hold office for six years, and shall be eligible for reappointment, but shall not hold office for more than twelve years.

7. At least one-sixth of the ordinary members of the General Board and of the Executive Committee shall retire annually.

In the case of the General Board, the retiring ordinary members shall be those who have not attended a meeting of the Board for two years, together with so many other members of the Board, selected by seniority, as may be necessary to bring the number of retiring members up to one-sixth of the whole number of ordinary members of the Board.

In the case of the Executive Committee, the retiring ordinary members shall be those who have not attended one-half of the meetings of the Committee during the previous year, together with so many other members of the Board, selected by seniority, as may be necessary to bring the number of retiring members up to one-sixth of the whole number of ordinary members of the Board.

No retiring member of the General Board or of the Executive Committee shall be eligible for reappointment until at least one year has elapsed from the date of his retirement.

The President and Council shall have power to remove from the General Board and from the Executive Committee any member of either whom they may judge to be disqualified.

Vacancies on the General Board or on the Executive Committee due to death, resignation, or removal by the President and Council of the Royal Society, shall be filled by the President and Council of the Royal Society, provided always that—

(1) Any person so appointed shall, for the purposes of the regulations for retirement from the Board or Committee, be regarded at the time of his appointment as having served for the same period as the member to whose place he succeeds.

(2) If the vacancy on the General Board be caused by one of the persons nominated as fitted to represent commercial interests ceasing to be a member of the Board, the President and Council of the Royal Society shall choose his successor from among a list of names recommended by the Councils of the Institutions named in Section 4.

(3) If a vacancy on the Executive Committee be caused by one of the persons nominated as fitted to represent commercial interests ceasing to be a member of the Committee, his successor shall either be selected from among those members of the General Board who were nominated as fitted to represent commercial interests, or shall be nominated by the President and Council of the Royal Society after consultation with the Councils of the Institutions named in Section 4.

The President and Council of the Royal Society shall determine the order of the seniority of the members of the first General Board and of the first Executive Committee for the purposes of the regulations for retirement.

*The Executive Committee.*

8. The Executive Committee shall have the immediate management of the National Physical Laboratory; shall appoint and dismiss the officials, except the Director; and shall determine the nature of the work to be undertaken from time to time.

*The General Board.*

9. A meeting of the General Board shall be held in October, at which the Executive Committee shall present a report on the work and finances of the National Physical Laboratory during the year ending on the preceding September 30. Copies of this report shall be circulated among the Members of the General Board at least one week before the meeting, and after the meeting shall be forwarded to the President and Council of the Royal Society, together with any further report, resolutions, or recommendations which may be added by the General Board.

The Executive Committee shall also lay before the General Board at its meeting in October a statement as to the work which it is proposed to undertake in the Laboratory during the ensuing year. This statement shall be circulated among members of the Board at least a week before the meeting; and the General Board may make such recommendations relative to the statement, or to the future work of the National Physical Laboratory, as they may think fit.

These recommendations shall be laid before the Executive Committee for their consideration.

*Sub-Committees.*

10. The Executive Committee may from time to time appoint Sub-Committees, of which the members shall not necessarily be members of the Executive Committee or of the General Board, either to superintend or to assist in certain specified investigations, or to superintend some department of the National Physical Laboratory.

*The Director.*

11. The Director of the National Physical Laboratory shall be appointed by the President and Council of the Royal Society after consultation with the Executive Committee, on such terms as the President and Council may determine, and shall be removable by the President and Council. He shall be responsible to, and shall take instructions from, the Executive Committee, but, subject to such instructions, he shall have the sole direction and control of the officials of the National Physical Laboratory and of the work done within it.

The Executive Committee may delegate its power of appointing and dismissing the officials of the Institution to the Director in such cases as it may think fit.

The Director shall neither be allowed nor be called upon to undertake work not connected with the National Physical Laboratory, except with the consent of the Executive Committee.

*Finance.*

The Royal Society shall open a banking account, to be called "The National Physical Laboratory Account of the Royal Society," into which all sums received by the Executive Committee for the purposes of the Institution shall be paid. The Treasurer of the Royal Society shall also pay into this account all sums received by him for the said purposes, after deducting therefrom such amounts as he shall be directed by the President and Council, with the approval of the Treasury, to retain for the purpose of defraying any expenses which the Royal Society may incur in the exercise of its control of the Institution.

The Executive Committee shall be empowered to draw on this account for the purposes of the Institution by

cheques signed by such members of the Executive Committee as may be authorised by the Committee to do so.

*Legal Proceedings.*

Any legal proceedings with regard to the affairs of the Institution, which it may become necessary to institute or defend, shall be instituted or defended by the Solicitors of the Royal Society, in the name and on behalf of the Royal Society upon the instructions of the Executive Committee, but no such proceedings shall be instituted or defended without the order of the President and Council of the Royal Society.

*The Kew Observatory Committee of the Royal Society.*

"The Kew Observatory Committee of the Royal Society," incorporated under the Companies Act, 1867, shall be wound up; and the property thereof shall be held by the Royal Society for the purposes of the Institution.

## CHEMICAL TECHNOLOGY.

*Outlines of Industrial Chemistry.* A Text-book for Students. By Frank Hall Thorp, Ph.D., Instructor in Industrial Chemistry in the Massachusetts Institute of Technology. Pp. xx + 541. (New York: The Macmillan Co. London: Macmillan and Co., Ltd., 1898.)

IN writing a book such as the present, the author's main difficulty must be in deciding what to omit. The number of industries in which chemistry plays a more or less important part is so large, and their nature so varied, that it would appear to be almost impossible to give even a moderately satisfactory account of them within the limits of one volume. By omitting metallurgy altogether, and condensing the preparation of the artificial organic dye-stuffs into a little over eight pages, the author succeeds in finding space for the essentials of the majority of the remaining chemical industries. The omission of metallurgy is justified by the facts that this subject is usually taught independently, and that several good short text-books dealing with it already exist. The hemistry of the artificial organic colouring matters is generally included in courses of lectures on organic chemistry, and, presumably for similar reasons, no mention is made of the majority of the pharmaceutical and photographic chemicals.

An introductory section contains a general account of the apparatus employed in performing such common operations as evaporation, filtration, distillation, calcining, and so on, on the large scale. The diagrammatic sketches employed in this section, and throughout the book, are very clear and are calculated to be of much more service to a student than elaborate illustrations of the outside of the apparatus or even complicated working drawings would be. The two cuts on pp. 12 and 13, representing filter-presses, might with advantage have been replaced by diagrams.

After a brief account of the main facts about fuels and water, the different chemical industries are considered, about equal space being devoted to those dealing with norganic and those dealing with organic substances. The accounts of the origin and properties of the raw materials, and of the different operations and transformations through which they pass on their way to the finished products, are clear and concise; in most cases the author has succeeded admirably in subordinating mere detail whilst bringing out clearly the essential factors on which the success of the process depends.

The treatment of some of the more recent developments of technical chemistry is not quite so satisfactory as that accorded to the older industries; the account of the electrolytic processes for the preparation of alkalis and chlorine being perhaps the least satisfactory chapter in the book. The author of a work on industrial chemistry is, of course, hampered to some extent by the natural and inevitable reticence of the inventors of new processes; but, even allowing for this, the chapter might have been improved by a wider acquaintance with the recent literature of the subject. This, in passing, is true, though to a less extent, of the chapter dealing with the cyanide industry in which so much progress has been made of late years.

In speaking of the Deacon chlorine process, on p. 99, the author remarks that since the reaction between hydrochloric acid and oxygen evolves heat, the temperature of the tower in which the reaction occurs should "theoretically" be maintained without further heating, but that this is not the case. In reality, of course, the whole thing depends on the relation between the amount of heat evolved by the chemical change and that lost by radiation, convection, and conduction. He goes on to say:—

"Theoretically, too, all the chlorine of the hydrochloric acid should be recovered, but practically the reaction is far from complete."

Since it is well known that the reaction

$$2HCl + O = H_2O + 2Cl$$

is reversible, an equilibrium must tend to be established; this equilibrium will not be displaced by the presence of a catalytic agent (which merely accelerates the velocity with which the equilibrium is approached), so that the practical result is only in disaccord with the incorrect theory.

These are, however, but minor blemishes in a book which attains a very high average of excellence. We are not acquainted with any other book in English which covers the same ground, and there is no doubt that it will prove to be of great service to all persons interested in technical chemistry, and more especially to the students and teachers to whom it most directly appeals. T. E.

## VOLCANOES.

*Volcanoes: their Structure and Significance.* By T. G. Bonney, D.Sc., LL.D., F.R.S., Professor of Geology at University College, London. Pp. 337. With 12 Plates, a Map, and 21 Illustrations in the Text. "The Progressive Science Series." (London: John Murray. New York: G. P. Putnam's Sons, 1899.)

IN this work the author has succeeded in giving, within convenient limits, a clear and very readable account of the present state of vulcanological science. The work is not burdened with scientific details nor made unattractive by a too technical terminology; but it nevertheless contains a trustworthy discussion of the most recent researches of geologists, and their latest views upon questions connected with these very interesting natural phenomena.

The first chapter, entitled "The life-history of vol-

canoes," contains succinct descriptions of a number of celebrated volcanic outbursts, including that of Vesuvius in A.D. 79, and later eruptions, of Monte Nuovo in 1538, of Stromboli, Bandai-san in Japan, Galoongoon in Java, Krakatoa, Kilauea in the Sandwich Islands, Skaptar Jökull in Iceland, Cotopaxi, Graham Island, and Bogosloff in Behring's Sea; lastly, of the mud volcanoes of Baku, and of Krabla in Iceland, and the geysers of the Yellowstone Park. These examples are admirably chosen to illustrate the varied manifestations, and successive phases of volcanic activity, and serve at the outset to give the student a clear idea of the nature and sequence of the phenomena, which it is the object of the work to explain.

The second chapter deals with "The products of volcanoes," and in it the author has evidently experienced some difficulty in maintaining the popular character of the work, while at the same time supplying accurate petrographical information. The explanation of mineral and rock names being relegated to a glossary, a fairly complete sketch is given of the classification and nomenclature of the igneous rocks. The admirable photographs of rock-sections in this part of the work serve to make the descriptions more intelligible.

In the third chapter, on "The dissection of volcanoes," an account is given of the results obtained from the study of volcanic piles in various stages of degradation under the agencies of denudation. Commencing with the "puys" of Auvergne, which Prof. Bonney describes from personal observation, and going on to the Eifel with its crater lakes, the great lakes of Central Italy and Oregon are alluded to, and then the more or less ruined volcanic cones, and crater rings of Santorin, Etna, and other districts are referred to, to illustrate the salient features of volcanic structures; and in the end illustrations are taken from the still more ruined volcanoes of central Scotland and Hungary, and from the structures which have received the name of laccolites in the western territories of the United States, and the midland district of England.

The next chapter is on "The geological history of British volcanoes," and attempts a chronological sketch of volcanic activity in the British Islands. Prof. Bonney in the main adopts the results arrived at on this subject by the officers of the Geological Survey, though he points out that many of their conclusions are not free from doubt. The sixth chapter, which gives a sketch of "The distribution of volcanoes," brings the descriptive portion of the book to a close. In this part of the work, much information has been incorporated which has been obtained by travellers and others during the last twenty years, and since the time at which most of the earlier English treatises on vulcanology have appeared. The general account of volcanoes all over the globe, with the discussion of the main features of their geographical distribution, is as complete and full as could be expected in some eighty pages, and enables the author to marshal a number of facts which are of the greatest service in leading up to the theoretical speculations to which the seventh and last chapter are devoted.

In referring to Prof. Bonney's remarks upon volcanic theories, it is only fair to point out that he himself admits that he is unable to supply "any complete theory of vulcanicity," and that he thinks we must wait for some time before any such theory, which will satisfy all the conditions of the problem, will be found. To use his own words:—

"We are, I think, in this position: We have ascertained a number of important facts; many of these suggest conclusions, but some of the latter seem at present difficult to reconcile and harmonise. Indeed it is my opinion that either some link in the chain of evidence still remains to be discovered, or the relation of those which we know is not yet fully understood. In other words, we do not seem to be in a position to put forward a complete explanation of vulcanicity. Nevertheless, I am sanguine that, to borrow an appropriate phrase from a child's game, 'we are getting warm,' and that our successors, by the end of the first quarter of the coming century, will have got much nearer to the solution of the problem."

In spite of this disclaimer on the author's part of any ability to propound a complete theory of vulcanicity, the concluding chapter of the work may be scanned alike by the general reader and the student of science with much profit. An account is given of numerous speculations upon the various portions of the question of vulcanicity, which have of late years attracted considerable attention, and the author's criticisms and suggestions are well worthy of perusal and consideration.

The volume, which is one of the handsome "Progressive Science Series," is admirably printed and fully illustrated; it constitutes a valuable addition to the popular books of science of the day. J. W. J.

## OUR BOOK SHELF.

*Recueil de données numeriques publié par la Société française de Physique, Optique.* Par H. Dufét. Deuxième Fascicule. Propriétés optiques des Solides. Pp. vi + 367. (Paris: Gauthier-Villars, 1899.)

THE data collected in this volume should prove of value in physical and chemical laboratories. The first section contains the indices of refraction, and their variation with temperature, of calcite, quartz, fluorine, rock-salt, sylvine (potassium chloride), and common alum. The second collection of tables comprises determinations of the refractive indices, at ordinary temperatures and for various wave-lengths, of glasses of known chemical composition. The optical properties of solid inorganic substances are tabulated in the third section, and of organic bodies in the fourth. These two sections occupy the greater part of the volume, and they should be of particular service to mineralogists and chemical crystallographers. Tables on the influence of temperature on the optical properties of solids, and on the indices of some metals and metallic compounds conclude the work.

*The Natural Mineral Waters of Harrogate.* By F. W. Smith, M.D. Pp. 101. (London: Dawbarn and Ward, 1899.)

DR. SMITH considers the natural waters of Harrogate chemically, therapeutically, and clinically, with reference to their suitability for drinking and bathing purposes. He maintains that the springs of Harrogate compare very favourably with those of Baden-Baden, Homburg and Kissingen, and that there is no need for invalids to run the risk of a journey to the Continent. Full analyses, by trustworthy chemists, are given of all the varieties of mineral waters with which this Yorkshire spa is endowed, and much valuable information concerning the local rainfall, temperature and mortality should cause this well-illustrated volume to take its place as a handy guide for "the doctors of this country," to whom Dr. Smith dedicates his work.

## LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### A Measure of the Intensity of Hereditary Transmission.

THE possessors of certain hereditary characters are unquestionably *sub-prolific;* that is, they eventually contribute less than their average share to the stock of the future population. It may be that they die before the age of marriage, or that they are sexually unattractive or unattracted, or that if married they are comparatively infertile, or that if married and fertile the children are too weakly to live and become parents. It is very probable, though I have no trustworthy facts to confirm the belief, that persons affected with hereditary insanity are sub-prolific because their families, if they have any, are apt to contain members who are afflicted in various ways that render them less likely than others to live and to marry. But I do not propose to go into the details of this or of any other malady, but merely mention it as an illustration of what is meant, when I assume that the possessors of some particular characteristic, not necessarily a morbid one, and which may be called A, are sub-prolific on the average.

It is a familiar statistical fact that the characteristics of a population, taken as a whole, who live under uniform conditions, change very little during many successive generations. So many per million of them are always found to be affected in this way, so many per million in that. The birth-rate continues the same, so does the death-rate; similarly as regards the various kinds of accident, and also, it may be inferred, as regards each form of disease, though it would be difficult to prove this in all cases, owing to improvements in diagnosis and nomenclature which make the statistics of disease for one period not comparable on strictly equal terms with those of another. It is therefore reasonable to discuss what might occur in an ideal population, which we will call P, whose characteristics are absolutely unchanged during successive generations, and to make such small corrections in the results as the conditions may require when dealing with real populations.

P and A being thus defined, it is obvious that the characteristic A must be transmitted with exceptional intensity in P. The possessors of A leave comparatively few descendants, consequently those few must be over-richly endowed with A; otherwise the number of the possessors of A would steadily diminish, and a P population would be impossible. Wherever a P population occurs, there must exist an inverse relation between the intensity with which A is hereditarily transmitted, and the prolific faculty of those who possess it.

This consideration may be of practical importance to actuaries in enabling them to estimate more justly than at present, the weights to be assigned to different hereditary diseases. It is a most difficult and delicate matter to attack this question directly, namely by making exhaustive inquiries into the life-history of all the near relatives of those who suffer from any serious hereditary malady. The difference in the results arrived at by different inquirers proves this, and shows the need of some second and independent method of investigation. The above considerations supply such a method in all cases where the frequency of the disease is found to have been approximately constant during successive generations of the population taken as a whole.

All that will then be needed, is to find how far those affected by the disease in question have been prolific, testing their capacity in that way by the number of their adult descendants in (say) the *second* generation, those in the first generation indicating little more than their fertility, which, as the children may be weakly, is not the same thing as the capacity of the parents for contributing to the future population. When the descendants in the second generation are neither more nor less numerous than the generality, the intensity of the transmission of the disease would be the same as that of any neutral quality, such as a moderate difference of stature. But if those descendants were more numerous than the generality, the intensity of transmission must be less than the average, while if the descendants were less numerous, the intensity would be greater.

It must be clearly understood that this method is of general application, and is not intended to be confined to morbid characters only. FRANCIS GALTON.

### Triboluminescence

THE interesting list of substances mentioned in to-day's review in NATURE of a paper on the subject of the above phenomenon, mentioning as substances in which it is conspicuous, cane-sugar, saccharin, hippuric acid, and some still more complex organic bodies, might lead one to suppose that only substances of an organic nature, in a crystalline state exhibit the kind of triboluminescence seen as a flash of light when a crystal of such substances is crushed between two glasses. But this is not quite exclusively the case, because crystals of uranium-nitrate, and perhaps other crystallised salts of uranium, emit a very bright greenish-yellow flash when pressed to pieces between glass plates. The property seems permanent in these crystals, and it is also apparently independent in them of chemical impurities, since any crystallised sample of the nitrate, as far as I have tried, shows the light flash very strongly, without any apparent loss of brightness by long keeping.

The ruddy light which gleams from under glass or from a flint pebble when ground with strong pressure on a grindstone, must apparently be a true example of luminescence produced by friction, since it is equally visible under water on a thoroughly wet, as on a dry, grindstone, where it can hardly be supposed to result from high temperature producing actual incandescence. But examples of crystals which emit light by fracture do not, it appears, present themselves in nearly such abundance among mineral substances, as they have now been shown in the above-mentioned paper to do in so many cases among organic bodies.

A rather interesting observation of thermoluminescence once befel me while making trials of that property in minerals; and as it may afford, perhaps, a ready means of tracing lime or calcareous ingredients in certain minerals, it may be useful to mention it here, although the mode of excitation used in that instance was not by crushing or rubbing, but by heating the material. Some fine dust and grains obtained from the interior portion of the mass of the Middlesborough aërolite, when the meteorite was first being chemically and microscopically examined, were found, to my considerable surprise, to glow quite distinctly, though not very brightly, with yellowish-white light, when sprinkled in the usual way for these experiments on a piece of nearly red-heated iron in the dark. No such luminescence would, I believe, be evolved by that means from pure terrestrial specimens of the pair of double silicates of magnesia and iron (olivine and bronzite, much less from the moderate sprinkling of nickel iron, and perhaps of iron-sulphide found with them), of which the stony matter of the meteorite in the main consists. But as its stony mass was considered, in the exact chemical analysis of the meteorite made by Dr. Flight,[1] to contain probably, besides, an appreciable amount of labradorite or lime-felspar, the source of the light may have been this calcareous ingredient of the stone, as calciferous rocks and minerals, for the most part, shine brightly with various shades from light- to reddish-yellow, in the dark, when strongly heated. To whatever chemical materials in the stone, however, the light was really due, it afforded, at all events, clear proof that no heat of exceedingly high temperature can ever have penetrated to the interior of the meteorite, even when it was passing at its fall, in a fireball through the atmosphere, since the time when it was broken off from some parent rock and projected on a celestial course about the sun; for a very moderate degree of heat suffices to expel completely from minerals of these luminescent natures all the store of thermoluminescent energy which, either originally communicated to them from without by radiation near some exposed or denudated surface, or else contracted by them in some more mysterious way at great subterranean depths, they more or less abundantly possess. A. S. HERSCHEL.

Observatory House, Slough, April 27.

### The New Zealand Godwit (*Limosa novæ-zelandiæ*).

THE Maori of New Zealand have an ancient saying or proverb, "Who can tell where the kuaka (the godwit) has its nest?" No doubt the Maori were well acquainted with the singular habit of these birds, in that they leave the shores of New Zealand, for a distant land across the seas, about the same time that other migratory birds, which have wintered on the Pacific Islands located nearer the tropics, are nesting and

[1] *Proceedings* of the Royal Society, vol. xxxiii., p. 347, February 1882.

rearing their young in the New Zealand forests, to which country they periodically return for the summer season. Such, for example, are the long-tailed cuckoo and the small bronze-cuckoo, known to the Maori as "the bird of Hawaiki"—that is, the bird who returns to the land from whence the Maori ancestors originally came.

Our kingfisher also moves northward in the autumn, and may likewise leave for a warmer country. These latter birds conduct their migrations as we should expect—that is, they reverse the conduct of their flight to those birds which live in northern latitudes, and we feel that their natural instincts are working according to rule. But the kuaka, not satisfied to pass the winter in a warmer country, must actually have two summers—one in New Zealand and a second in Northern Siberia, where it is said to have its breeding-place. Any way, it leaves in countless numbers from the north-east point of New Zealand, from almost the very place where the spirits of the dead Maori are supposed to take their departure to the other world (Reinga). For which reason the bay on the shore of which the birds assemble before flight is named by Europeans "Spirits' Bay."

The Polynesian mariner may in former times have guided his migrations by observation of the place of departure and arrival of birds of passage, also from the particular dates of such occurrence, and from the circumstance that the winds at that time were most favourable for travel in such particular directions. The spirits of their dead may have been supposed to return to the original birthplace of the race; and the nearest point of departure would be that from which the birds also departed.

But do any migratory birds other than the kuaka go further north than Tahiti, Rarotonga, Samoa, and the Fijis?

I always understood that no bird from either the north or the south temperate zones ever voluntarily crossed the tropics, and to me it seems a fable that even the kuaka should do so.

Whence comes the hereditary knowledge that should lead the kuaka half over the world to find a suitable breeding-place? Why does it not go in search of an Antarctic continent, as should be the natural sequence of events? Are not the high lands and alpine valleys of New Zealand where the dotterel, the red-breasted plover, the stilt-plover, oyster-catcher, &c., make their nests, equally suitable for the godwit?

Where does the European godwit (*Limosa lapponica*) breed? and is it not said that the nesting-place of the European knot (*Tringa canutus*) has never been discovered?

That the New Zealand godwit starts in a northerly direction in its migration is assured; but who has traced its course onward, as following the shores of China, it is making its way to lonely steppes in Siberia?

That these birds should winter during a New Zealand summer, and then leaving should pass through both temperate and torrid zones, and still onward to the confines of the north frigid zone to nest and summer, is truly marvellous. Will any reader of NATURE kindly contribute to our knowledge of the nesting-place of the godwit or the knot, or remark on other points at issue?

TAYLOR WHITE.

Wimbledon, Hawkes Bay, N.Z., February 9.

[In reference to the above, the British Museum possesses a single egg of the knot, said to be one out of a clutch of four obtained at Disco Island, Greenland. Colonel Feilden has good grounds for believing that this bird nests in the New Siberian Islands.—ED.]

## The Indian Musk-Shrew.

THE old yarn about the tainting of wine in bottle by the common Indian shrew (*Crocidura coerulea*)) seems to die hard, since "W. T. B." has had to correct it again in your issue of this week. The account of a crucial and deliberate experiment may be another nail in its coffin.

I kept wine in small chambers off my office, in a locked basket, ventilated at the ends, for use at luncheon. One day I opened it, and found a musk-shrew coiled up on a napkin, and did not disturb him, nor he himself. Next day I impanelled an unconscious jury; and we found the wine perfectly good. The musk-rat had been there in the morning, but had received a quiet hint to go. When my guests were gone, I wiped a glass with his napkin, filled it with wine from the same bottle, and found this too musky to swallow.

The wine was a sound Pommard from Treacher and Co., Bombay, with capsuled corks bearing their stamp.

I do not know whether it was bottled in Europe or in India.

I believe that the commonest cause of the musk-taint in wine is the wiping of the glass with a clout that has been picked up out of a corner, where the musk-shrew has laid on it.

Even in the best houses in India native servants will often use very little care about the cleanliness of "glass-cloths"; and when one that has served to clean a lamp or shelter a shrew is next used upon a wineglass, you have *vera et sufficiens causa* for spoilt wine—and temper.

I have a note on this somewhere in the *Journal* of the Bombay Natural History Society; but it is buried out of sight in some back volume, as my experiment took place about twenty years ago. I may add that the place of it was Ahmadabad, in Gujarat.

W. F. SINCLAIR.

102 Cheyne Walk, Chelsea, London, S.W., May 5.

## Mammalian Longevity.

SINCE my letter on this subject in NATURE of March 23, I have noticed that a slight change in the formula—the reduction of the constant from 10·5 to 10·1—gives much better results. The agreement is now very close indeed. The amended statement now runs as follows:—

The full term of life in any mammalian species is equal to 10·1 times its period of maturity divided by the cube root of the period, or 10·1 times the cube root of the square of the period.

We get the following results from its application:—

| Animal. | Observations. | | | f. t. l. by formula. | Other observations. |
|---|---|---|---|---|---|
| | Authority. | p. m. | f. t. l. | | f. t. l. |
| Dom. Mouse .. | Dr. Ainslie Hollis. | ·25 yr | 4 yr. | 4 (4·01) | |
| Guinea-pig ... | Flourens. | ·583 | 6–7 | 7 (7·05) | |
| Lop-Rabbit— | | | | | |
| Buck... ... | R. E. Edwards. | ·75 | 8 | 8 (8·3) | |
| Doe ... ... | R. E. Edwards. | ·67 | 8 | 8 (7·7) | |
| Goat ... ... | Pegler. | 1·25 | 12 | 12 | |
| Fox ... ... | St. G. Mivart. | 1·50 | 13–14 | 13·25 | |
| Cat ... ... | Jennings. | 2 | 15 | 16 | |
| Cattle ... ... | Dr. Ainslie Hollis. | 2 | 18 | 16 | 14, Gresswell. 15-20, Flourens. |
| Large Dogs ... | Dalziel. | 2 | 15 | 16 | 15-20, Flourens and others. |
| Thor. Horse ... | Dr. Ainslie Hollis. | 4·5 | 30 | 28 | |
| Pigs ... ... | James Long. | 5 | 30 | 30 | |
| Hippopotamus | Chamb. Encyc. | 5 | 30 | 30 | |
| Lion ... ... | St. G. Mivart. | 6 | 30–40 | 33 | |
| Hunter... ... | Blaine. | 6·25 | 33 | 34 | |
| Arab Horse ... | Dr. Ainslie Hollis. | 8 | 40 | 40 | |
| Camel ... ... | Flourens. | 8 | 40 | 40 | |
| Man ... ... | Buffon. | 25 | 90–100 | 86 | 100, Flourens. 75, Farr. |
| Elephant ... | Darwin. | 30 | 100 | 98 | |
| Elephant ... | C. F. Corder and Indian hunters. | 35 | 120 | 108 | 100, Darwin. |

In this table, p. m. stands, as before, for period of maturity, and f. t. l. for full term of life.

In the first table another statement dealing with the cat was also given, on the authority of Dr. Mivart, which is excluded from this, since the period mentioned—one year—obviously refers to the animal's period of puberty, not its period of maturity, as is indicated by Dr. Mivart's expression: "The domestic cat begins to be ready to reproduce by the end of the first year of her life. . . ."

The age of the hunter, calculated from Blaine, was given in the previous table at thirty-five, and in this it is given at thirty-three. Blaine states that a horse of thirty years is relatively as old as a man of eighty, and a horse of thirty-five as a man of ninety. The first formula gave about ninety for man, and the corresponding age for the horse was therefore thirty-five; but the corrected formula gives eighty-six for man, which corresponds to thirty-three in the horse.

I agree with Dr. Ainslie Hollis that Buffon's 90–100 years for man is too long; but, on the other hand, seventy-five—the period given by Dr. Hollis from Dr. Farr's calculations—seems much too short. The great majority of persons have their lives cut short by disease, the nervous strain of life, &c., and do not live to anything like the full term of life. Were it not for such influences as these, most persons at seventy-five would probably still possess a considerable degree of vitality, and should be able to look forward to many years of life. Furthermore, Farr's cal-

culation is based on what seems a faulty method. The average of life, about fifty years, is taken, and the expectation of life (in reality a somewhat larger figure), twenty-five years, is added, making up seventy-five, the manifest assumption being that the full term of life of a species is equal to its *average* life plus the *expectation of life* at that age, a conception for which I know of no physiological justification. Eighty-six to eighty-seven years, the period given by the formula, probably represents with fair accuracy the average age at which people would pass from life by senile decay if their lives were not shortened by deleterious influences and conditions. ERNEST D. BELL.

### "Primitive Constellations."

REFERRING to your reviewer's hostile notice of my work, "Primitive Constellations," I have seldom realised the strength of my general position until I have seen some attack on it. Against my main contention, *i.e.* the identity of various Greek and Babylonian constellations, he has nothing to say, except that I start with my "theory ready made." Really, he does me much honour. Am I the inventor of the "theory" that, *e.g.*, the signs of the Zodiac were derived from Babylonia? But, leaving nine-tenths of the book with merely a little abuse, he has much to say on the transliteration of Babylonian words, and expresses great scorn because, following Prof. Sayce, I deliberately write *sa*, and not *sha*, and so on. He says I "really ought to know there is no *h* in Assyrian." Indeed. I am at present away from books, but happen to have Sayce's "Assyrian Grammar" at hand. At p. 46 I read, "*a, ha* . . . *h.* , *ah, hi, h.*" Again, I am perfectly aware of the force of "the determinative particle *ki*," and, in a book for general readers, have naturally chosen to write "Barsipki," not "Barsip$^{ki}$," "Suanaki," "Tintirki," &c. If the critic had endeavoured to refute my general proposition, or had carefully examined my treatment of any particular constellation figure, *e.g.* the *Arrow*, how much more useful it would have been. But a policy of pin-pricks does not venture on this.

Berry Pomeroy, Boscombe, April 18. R. BROWN, JUN.

THE writer of the review did not suggest that Mr. Brown had discovered the Babylonian origin of the signs of the Zodiac. The theory which the reviewer laid to his charge was to the effect that the Greeks of the pre-Homeric and Homeric ages had a full knowledge of the constellations known to their descendants in Ptolemaic times; and, further, that they obtained such knowledge at this early period from the Babylonians through intercourse with the Phœnicians and the "Hittites." It is from this theory that the reviewer entirely dissents. Mr. Brown's wholesale assertions that representations of animals in early Greek art are astronomical symbols it was thought might be charitably explained by supposing that he began his studies with this part of his theory "ready made." Of the two cuneiform signs which Mr. Brown cites as proving the existence of the *h* in Assyrian, the first only represents the vowel *a*, the second is only used to indicate the smooth breathing; that he should rely on a grammar published more than twenty years ago shows that he has not made himself acquainted with the recent literature on this subject. It is satisfactory to learn that Mr. Brown is aware of the force of the determinative particle *ki*; but to transliterate such a determinative (which was not pronounced) as though it formed a syllable of the word to which it is attached is, to say the least, misleading—particularly so in a book for general readers. Mr. Brown's numerous blunders in citing Hebrew, Phœnician, and Assyrian words, show that he is not acquainted with these languages at first hand; and it was stated that such a knowledge is essential to a writer who treats the subject of Babylonian astronomy from the linguistic side.

## *THE ROYAL SOCIETY SELECTED CANDIDATES.*

THE following are the names and qualifications of the fifteen candidates selected by the Council of the Royal Society, to be recommended for election into the Society this year:—

W. F. BARRETT,

F.R.S.E., M.R.I.A., Professor of Experimental Physics in the Royal College of Science for Ireland, Memb. Physical Society, Royal Dublin Society, and of General Committee of the British Association. Author of numerous original investigations and papers; amongst them are:—"The discovery of certain physical phenomena produced by the contact of a hydrogen flame with various bodies, and its application as a delicate chemical re-agent" (*Phil. Mag.*, November, 1865); "The discovery and investigation of a serious source of error in the determination of the absorption of heat by liquids" (*ibid.*, September, 1868); "The discovery and investigation of sensitive flames" (*ibid.*, March and April, 1867); "The application of sensitive flames as a delicate acoustic re-agent in illustrating the laws of the reflection, refraction, and interference of sound-bearing waves and the detection of inaudible vibrations" (*Proc. Roy. Dubl. Soc.*, January, 1868; *Science Review*, April, 1867; NATURE, May, 1877); "The discovery of recalescence and other molecular changes in iron and steel when raised to a bright heat" (*Phil. Mag.*, December, 1873; Brit. Assoc., 1890); "The investigation of the molecular changes accompanying the magnetisation of iron, nickel, and cobalt, and the discovery of the retraction of nickel, and the elongation of cobalt by magnetisation, with the determination of its amount" (*Phil. Mag.*, December, 1873, and January, 1874; Brit. Assoc., 1873, 1874, and 1882; *The Electrician*, October, 1882; NATURE, October, 1882); "The investigation of the magnetic properties and the determination of the physical constants of various alloys of manganese steel" (Brit. Assoc., 1887 and 1889; *Proc. Roy. Dubl. Soc.*, November and December, 1889, March, 1886, and in *The Electrician*). Also brief papers on the spheroidal state (*Proc. Roy. Dubl. Soc.*, December, 1877); on the magnetic properties of columnar basalt (*ibid.*, December, 1889), and on the magnetic moment of ingots of manganese steel (*ibid.*, December), &c.

CHARLES BOOTH,

Hon. Sc.D. (Camb.), Merchant and Shipowner. As having applied Scientific Methods to Social Investigation, exemplified by:—(1) A Study of Changes in the Occupations of the People in England, Scotland, and Ireland, from 1841 to 1881 (*Journ. of Statistical Soc.*, 1886); (2) A Study of the Condition of the Aged Poor in England and Wales from Official Statistics and Extended Private Enquiry ("The Aged Poor," Macmillan, 1894); (3) A Study of the Condition of the People of London, 1889 to 1899, in twelve volumes, of which nine are already published ("Life and Labour of the People in London," Macmillan).

DAVID BRUCE,

M.B., Surgeon-Major, Army Medical Staff. Has made important investigations relating to the nature and causes of Malta Fever, and discovered the micro-organism which is the cause of that disease, and proved its nature by experiment. Has successfully investigated the endemic disease of horses in Zululand, and proved the agency of the Tsetse Fly in producing it. Author of the following papers: "Discovery of a Micro-organism in Malta Fever" (*Practitioner*); "Sur une Nouvelle Forme de Fièvre rencontrée sur les Bords de la Mediterranée" (*Annales de l'Inst. Pasteur*); "On the Epidemic of Cholera in Malta during 1887" (*Trans. Epidem. Soc.*); "Report (to the Governor of Natal) on the Tsetse Fly Disease or Nagana" (1897); and a previous Report on the same subject; "Ueber die Virulenzsteigerung des Cholera Vibrio" (*Centralblatt f. Bacteriologie, &c.*). Eminent in Pathology and Bacteriology.

HENRY JOHN HORSTMAN FENTON,

M.A. (Camb.). Author of several papers on the action of hypochlorites and hypobromites on urea and other nitrogen compounds. Has made the remarkable discovery that hydrogen peroxide, although inactive alone, in presence of an iron salt, at once oxidises tartaric and other similar acids, carbohydrates, &c., giving rise to very characteristic products—a discovery of special importance in connection with plant metabolism, which he has elaborated with particular skill and thoroughness. His results are described in the following papers:—"Oxidation of Tartaric Acid in Presence of Iron" (*Trans. Chem. Soc.*, 1894); "A New Method of obtaining Dihydroxytartaric Acid, and the use of this Acid as a Re-agent for Sodium" (*ibid.*, 1895); "New Formation of Glycollic Aldehyde" (*ibid.*); "The Constitution of a New Dibasic Acid resulting from the Oxidation of Tartaric Acid" (*ibid.*, 1896); "A New Synthesis in the Sugar Group" (*ibid.*, 1897); "Properties and Relationships of Dihydroxytartaric Acid," I. and II. (*ibid.*, 1898); "The Oxidation of Polyhydric Alcohols in presence of Iron" (*ibid.*, 1899).

JAMES SYKES GAMBLE,

M.A. (Oxon.), F.L.S. Conservator of Forests, School Circle, N.W. Provinces, India, and Director of the Imperial Forest School, Dehra Dun. Fellow of the University of Madras, and *ex-officio* Fellow of the University of Allahabad. Author of a List of Trees, Shrubs, &c., of the Darjeeling District, Bengal (1st edit., 1877; 2nd edit., 1896); a Manual of Indian Timbers, published in 1881; a Monograph of the Bambuseae of British India, 1896. Also many papers on Forestry and on Botanical subjects in the "Indian Forester," which he has long edited.

ALFRED CORT HADDON,

M.A., M.R.I.A., F.Z.S. Professor of Zoology, Royal College of Science, Dublin. Vice-President of the Royal Zoological Society of Ireland. Member of Council of the Royal Dublin Society, Anthropological Institute and Folk-lore Society. Has considerably extended our knowledge of the Marine Fauna of Ireland (*Proc. Roy. Irish Acad.*, 1886–87). Received a grant from the Royal Society and spent eight months (1888–89) in studying the Marine Zoology, Geology and Ethnography of Torres Straits. Has made investigations upon British and Tropical Actiniaria (*Journ. Linn. Soc.*, xxi.; *Proc. Roy. Dubl. Soc.*, 1885–92, *Trans.*, 1889–92). Is the author of a memoir on "The Air-bladder and Weberian Ossicles in Siluroid Fishes" (with Prof. Bridge) (*Phil. Trans.*, 1893); "Report on the Polyplacophora collected by H.M.S. *Challenger* (Part XLIII., 1886); "Notes on the Development of Mollusca" (*Quart. Journ. Micros. Sci.*, 1882); and other papers on Marine Zoology. Has made a map and a geological survey of the Murray Islands, Torres Straits, which, with other geological observations, are published in the *Trans. Roy. Irish Acad.* in a joint memoir with Prof. Sollas and Prof. Cole. Has carried out extensive and detailed anthropological investigations on the mode of life, handicrafts, religion, and languages of the natives of Torres Straits (*Journ. Anthrop. Inst.*, 1891; *Proc. Roy. Irish Acad.*, 1893; *Folk-lore*, 1890; *Internat. Arch. f. Ethnogr.*, 1892–93). Has organized a scheme for the systematic study of Irish Ethnography (the Ethnography of the Aran Islands; Studies in Irish Craniology—Part I. Aran, II. Inishbofin. *Proc. Roy. Irish Acad.*, 1893–94). Has made an elaborate study of the evolution and degeneration and geographical distribution of the Decorative Art of British New Guinea (Cunningham Memoir Roy. Irish Acad.).

HENRY HEAD,

M.D. (Cantab.), M.A., M.R.C.P., M.R.C.S. Author of the following papers:—"Ueber positive und negative Schwankungen des Nerven Stromes" (*Pflüger's Archiv*, 1887); "Regulation of Respiration," Parts I.–II. (*Journ. Physiol.*, vol. x.); "On Disturbances of Sensation, with especial reference to the Pains of Visceral Disease" (Part I., *Brain*, 1893, Part II., *Brain*, 1894).

CONWY LLOYD MORGAN,

F.G.S. Professor of Biology and Geology, University College, Bristol, and Principal of the same College. Correspondent of the Academy of Sciences of Philadelphia and New York. As a geologist, Prof. Lloyd Morgan has done a considerable amount of original work in Pembrokeshire and the Bristol district. His chief claim to scientific distinction, however, rests upon his careful experiments and observations on the habits, instincts, and intelligence of Animals, and his critical study of the true biological significance of the facts and their bearing upon some of the most fundamental problems of Organic Evolution. The three volumes which he has published on these subjects are of very high merit, and, in the opinion of the signers of this certificate, place their author in the first rank as a philosophical biologist. Author of the following memoirs:—(1) "Animal Life and Intelligence," 1890; (2) "An Introduction to Comparative Psychology," 1894; (3) "Habit and Instinct," 1896; and of the following geological papers:—"On the Pebidian Volcanic Series of St. David's" (*Quart. Journ. Geol. Soc.*, vol. xlvi., 1890); "On the S.W. Extension of the Clifton Fault" (*ibid.*, vol. xli., 1885); and twelve geological papers in the *Proc. Bristol Nat. Soc.*, 1884–90, and other local scientific periodicals.

CLEMENT REID,

F.G.S., F.L.S. Geologist in the Geological Survey of England and Wales, and has served on the Staff since 1874. Awarded the Murchison Fund by the Council of the Geological Society in 1886. Has been Secretary and Recorder to the Geological Section of the British Association. Has added largely to our knowledge of the Lower Tertiary formations of the Isle of Wight and Dorset, the Pliocene deposits of Norfolk and the North Downs (including the fauna and flora of the Cromer Forest Bed), and the Glacial Phenomena of Norfolk and Sussex. To aid his researches he has made a special study of recent and fossil seeds (a subject previously much neglected), whereby much light has been thrown on the climatic conditions of later Tertiary times, and on the origin of the British flora. Author of Geological Survey memoirs on "Geology of the Country around Cromer," 1882; "Geology of Holderness," 1885; "Pliocene Deposits of Britain," 1890, and revised Tertiary portion of "Geology of Isle of Wight," 2nd ed., 1889. Also author of many original papers, including "Dust and Soils" (*Geol. Mag.*, 1884); "Norfolk Amber" (*Trans. Norf. Nat. Soc.*, 1884); "Origin of Dry Chalk Valleys" (*Quart. Journ. Geol. Soc.*, 1887); "Geological History of the Recent Flora of Britain" (*Ann. Botany*, 1888); "Pleistocene Deposits of Sussex Coast" (*Quart. Journ. Geol. Soc.*, 1892); "Natural History of Isolated Ponds" (*Trans. Norf. Nat. Soc.*, 1892); "Desert or Steppe Conditions in Britain" (*Nat. Science*, 1893); "Eocene Deposits of Dorset" (*Quart. Journ. Geol. Soc.*, 1896); "Report on Relation of Palæolithic Man to the Glacial Epoch" (Hoxne Excavation) (Brit. Assoc., 1896).

HENRY SELBY HELE SHAW,

LL.D. (St. And.), Engineer. Mem. Inst. C.E., Mem. Inst. M.E., F. R. Met. Soc., Harrison Professor of Engineering, University College, Liverpool. Senior Whitworth Scholar, 1876, and Miller Scholar of the Inst C.E. Distinguished for his acquaintance with Engineering and Mechanical Science. Inventor of integrating and power transmitting mechanism. Was the first Professor of Engineering at Bristol and afterwards at Liverpool. At Liverpool he organised the School of Engineering and designed and supervised the equipment of the Walker Engineering Laboratories, in which there are now nearly 100 day students under instruction. Author of "Theory of Continuous Calculating Machines" (*Phil. Trans.*, 1884); also of the following communications:—"On Small Motive Power" (Inst. Civil Engineers, 1880); "On the Measurement of Velocity for Engineering Purposes" (*ibid.*, 1882); "On Mechanical Integrators" (*ibid.*, 1885) (awarded the Watt Gold Medal and Telford premium); "Sphere and Roller Mechanism," jointly with Mr. E. Shaw (Brit. Assoc., 1886); "First Report on Graphical Methods in Mechanical Science" (*ibid.*, 1891); "Second Report on the Development of Graphical Methods in Mechanical Science" (*ibid.*, 1892); "Third Report on Graphical Methods" (*ibid.*, 1893); "Experimental Investigation of the Motion of a Thin Film of Viscous Fluid," appendix by Sir G. G. Stokes, F.R.S. (*ibid.*, 1898); "A New Instrument for Drawing Envelopes, and its Application to the Teeth of Wheels, and for other Purposes" (*ibid.*, 1898); "Rolling Contact of Bodies" (Roy. Inst., 1887, Friday evening Discourse); "The Motion of a Perfect Fluid" (*ibid.*, 1899, Friday evening Discourse); "Experiments on the Nature of Surface Resistance in Pipes and on Ships" (Inst. Naval Architects, 1897); "Investigation of the Nature of Surface Resistance of Water, and of Stream Line Motion under Certain Experimental Conditions" (*ibid.*, 1898) (awarded the Gold Medal of the Institution); "Experimental Marine Engine and Alternative-centre Testing Machine in the Walker Engineering Laboratory" (Inst. Mechanical Engineers, 1891); and other papers to the Society of Arts, Physical Society, and Societies in Bristol, Liverpool and elsewhere.

ERNEST HENRY STARLING,

M.D., F.R.C.P., Joint Lecturer on Physiology, Guy's Hospital, Lecturer on Physiology, London School of Medicine for Women. Distinguished as a Physiologist. Author of the following: "Electromotive Phenomena of the Mammalian Heart" (*Proc. Roy. Soc.*, vol. l., and *Internat. Journ. of Anat. and Physiol.*, vol. ix., with W. M. Bayliss); "Innervation of Mammalian Heart" (*Journ. of Physiol.*, vol. xiii., with W. M. Bayliss); "Fate of Peptone in Blood" (*Proc. Physiol. Congress, Liège*, 1892); "Physiology of Lymph Secretion" (*Journ. of Physiol.*, vol. xiv.); "Absorption and Secretion in Serous Cavities" (with A. H. Tubby, *ibid.*, vol. xvi.); "Nervous and Capillary Pressures" (with W. M. Bayliss, *ibid.*, vol. xvi.); "Mechanical Factors in Lymph Production" (*ibid.*, vol. xvi.);

"Action of Lymphagogues" (*ibid.*, vol. xvii.); "Vaso-Constrictors of Portal Vein" (with W. M. Bayliss, *ibid.*, vol. xvii.); "Intraventricular and Aortic Pressure Curves by a New Method" (with W. M. Bayliss, *Internat. Journ. of Anat. and Physiol.*, vol. xi.); "Osmotic Pressures and Physiol. Problems" (*Science Progress*, 1896); "Absorption from Pleural Cavities" (with J. B. Leathes, *Journ. of Physiol.*, vol. xviii.); "Production of Pleural Effusion" (*Journ. of Pathol.*, vol. iv.); "Absorption from Connective Tissue Spaces" (*Journ. of Physiol.*, vol. xix.); "Ligature of Portal Lymphatics and Injection of Peptone" (*ibid.*, vol. xix.); "Absorption of Indigo Carmine from Peritoneal Cavity" (*Proc. Physiol. Soc.*, 1898, Arris and Gale Lectures); "Physiol. of Lymph Formation," 1894; "Causation of Dropsy," 1896; "Pathol. of Heart Disease," 1897. Author of "Elements of Human Physiol.," 3rd edit., 1897; of the following articles in Schäfer's Text-book of Physiology: "Formation and Absorption of Lymph"; "Secretion of Urine"; "Special Muscular Mechanisms of Respiration, Alimentation, Micturition," &c. Editor of Metschnikoff's Lectures on Pathology of Inflammation. Joint Editor of the Collected Works of L. C. Wooldridge.

HENRY WILLIAM LLOYD TANNER,

M.A. (Oxon.), F.R.A.S., A.R.S.M., Professor of Mathematics and Astronomy in the University College of South Wales and Monmouthshire, Member (and sometime Member of Council) of the London Math. Soc. Distinguished as a mathematical investigator, author of several papers on "Differential Equations" (*Proc. Lond. Math. Soc.*, vols. vii., viii., ix., x., xi.; *Quart. Journ. Math.*, vol. xvi.; *Mess. Math.*, vols. v., vi., vii.); "On Determinants of $n$ Dimensions" (*Proc. Lond. Math. Soc.*, vol. x.); "On the Coordinates of a Plane Curve in Space" (*ibid.*, vol. xiii.); "On the Function $(ax + b)(cx + d)$" (*Mess. Math.*, vol. ix.); "On Spherical Trigonometry" (*ibid.*, vol. xiv.); "Sturm's Theorem" (*ibid.*, vol. xviii.); "Solution of $(a, b, \ldots, c) = (a^p, b^p, \ldots, c^p)$" (*ibid.*, vol. xix.); "Arbogast's Rule" (*ibid.*, vol. xx.); "Square Roots of Unity for a Prime Modulus" (*ibid.*, xxi.); "Quinquisection of $x^p - 1$" (*Proc. Lond. Math. Soc.*, vol. xviii.); "Cyclotomic Functions" (*ibid.*, vol. xx.); "Approximate Evolution" (*ibid.*, vol. xxiii.); "Complex Primes formed with Fifth Roots of Unity" (*ibid.*, vol. xxiv.).

RICHARD THRELFALL,

M.A., late Professor of Experimental Physics, University of Sydney, New South Wales. Author of the following papers: "On the Electrical Properties of Pure Sulphur" (in conjunction with Mr. Brearly, *Phil. Trans.*, 1896); "On the Conversion of Energy in Dielectrics" (*Physical Review*, vol. iv.); "On the Behaviour of Oxygen at Low Pressures" (*Phil. Mag.*, 1897); "On the Scattering of Light by Metallic Particles" (*ibid.*, vol. xxxviii.); "On an Approximate Method for Finding the Forces on Magnetic Circuits" (*ibid.*); "On the Electrical Properties of Pure Nitrogen" (*ibid.*, vol. xxxv.); "On the Elastic Properties of Quartz Threads" (*ibid.*, vol. xxx.); "On the Measurement of High Specific Resistances" (*ibid.*, vol. xxviii.); "On the Clark Cell as a Source of Small Constant Currents" (with Mr. Pollock, *ibid.*); "On the Specific Heat of the Vapours of Acetic Acid and Nitrogen Tetroxide" (*ibid.*, vol. xxiii.); "On the Theory of Explosives" (*ibid.*, vol. xxi.); "On the Velocity of Transmission through Sea Water of Disturbances of Large Amplitude caused by Explosives" (*Proc. Roy. Soc.*, vol. xlvi.); "On the Effect produced by the Passage of an Electric Discharge through Nitrogen" (with Prof. J. J. Thomson, *ibid.*, 1886); "Some Experiments on the Production of Ozone" (with Prof. J. J. Thomson, *ibid.*); "Laboratory Arts" (Macmillan and Co., 1898). Introducer of improvements in the Microtome.

ALFRED E. TUTTON,

F.C.S., Associate Royal College of Science. Member Mineral. Soc. Inspector, Science and Art Department. Has made discoveries in crystallography, and has invented instruments for research in this branch of science. Is the author of the following papers: "Connection between Atomic Weight of Contained Metals and the Magnitude of the Angles of Crystals of Isomorphous Series. A Study of the Potassium, Rubidium, and Caesium Salts of the Series $R_2M(SO_4)_2, 6H_2O$" (*Journ. Chem. Soc.*, 1893, p. 337: and *Zeits. für Kryst.*, vol. xxi., p. 491); "An Instrument for Grinding Section-Plates and Prisms of Crystals of Artificial Preparations Accurately in the Desired Directions" (*Phil. Trans.*, 1894A, p. 887, and *Zeits. für Kryst.*, vol. xxiv., p. 433); "An Instrument for Producing Monochromatic Light of any Desired Wave-Length, and its use in the Investigation of the Optical Properties of Crystals" (*Phil. Trans.* 1894A, p. 913; and *Zeits. für Kryst.*, vol. xxiv., p. 455); "Connection between the Atomic Weight of Contained Metals, and the Crystallographical Characters of Isomorphous Salts. The Volume and Optical Relationships of the Potassium, Rubidium and Caesium Salts of the Series $R_2M(SO_4)_2, H_2O$" (*Journ. Chem. Soc.*, 1896, p. 344; and *Zeits. fur Kryst.*, vol. xxvii., p, 113); "Comparison of the Results of the Investigations of the Simple and Double Sulphates, and General Deductions concerning the Influence of Atomic Weight on Crystal Character" (*Journ. Chem. Soc.*, 1896, p. 495; and *Zeits. für Kryst.*, vol. xxvii., p. 252); "Connection between the Crystallographical Characters of Isomorphous Salts and the Atomic Weight of the Metals Contained. A Study of the Normal Selenates of Potassium, Rubidium, Caesium" (*Journ. Chem. Soc.*, 1897, p. 846; and *Zeits. für Kryst.*): and of various papers in the *Journal* of the Chemical Society and other journals. Author of the following Memoirs, in conjunction with Prof. Thorpe: "Phosphorus Tetroxide" (*Journ. Chem. Soc.*, 1886, p. 833); "Phosphorus Oxide, Part I." (*ibid.*, 1890, p. 545); "Phosphorus Oxide, Part II." (*ibid.*, 1891, p. 1019); "Ueber Phosphoroxysulfid" (*Zeits. Anorg. Chem.*, 1892–5).

BERTRAM COGHILL ALLEN WINDLE,

M.D., M.A., D.Sc. (Dublin). Professor of Anatomy, Queen's College, Birmingham. Has devoted himself to the study of Human and Comparative Anatomy and Morphology; and has published the following works and papers on these and kindred subjects:—(1) "On the Embryology of the Short Muscles of the Manus and Pes of the Dog" (*Proc. R. Irish Acad.*, vol. iii.); (2) "The Embryology of the Short Muscles of the Human Hand" (*Trans. R. Irish Acad.*, xxviii.); (3) "On the Pectoral Group of Muscles" (*ibid.*, xxix.); (4) "Teratological Evidence as to the Heredity of Acquired Characters" (*Journ. Linn. Soc.*, xxiii.); (5) "On the Anatomy of *Hydromys chrysogaster*" (*Proc. Zool. Soc.*, 1887); (6) "On some Cranial and Dental Characters of the Domestic Dog" (in conjunction with Mr. Humphrys) (*ibid.*, 1890); (7) "On an Abnormal Arrangement of the Large Intestine" (*Journ. of Anat.*, vol. xx.); (8) "On Primary Sarcoma of the Kidney" (*ibid.*, xix.); (9) "On the Condition of the Brain in a case of Motor Aphasia with Deafness" (*ibid.*, new series, i.); (10) "Man's Lost Incisors" (*ibid.*, i.); (11) "Anomalies of Muscles and Nerves" (*ibid.*); (12) "Two Rare Tumours connected with the teeth" (*ibid.*); (13) "The Myology of *Erethizon epixanthus*" (*ibid.*, ii.); (14) "On the Arteries forming the Circle of Willis" (*ibid.*); (15) "On a Teratoma from the Sphenoid of a Calf" (*ibid.*); (16) "On the Myology of *Procyon cancrivorus*, and others of the Ursidæ" (*ibid.*, iii.); (17) "On the Origin of Double Monstrosities" (*ibid.*); (18) "On the Flexors of the Digits of the Hand" (*ibid.*, iv.); (19) "Ununited Epiphyses" (*ibid.*); (20) "On the Stylo-auricularis Muscle and Ligament" (*ibid.*, v.); (21) "On the Occurrence of an Additional Phalanx in the Human Pollex" (*ibid.*, vi.); (22) "On Identical Malformations in Twins" (*ibid.*); (23) "Sacculation of the Human Stomach" (*Proc. Birmingham Philos. Soc.*, v.); (24) "Myology of *Midas rosalia*" (*ibid.*); (25) "Myology of *Hapale Jacchus*" (*ibid.*); (26) "The Adductor Muscles of the Hand" (*ibid.*); (27) "The Extensors of the Manus in the Ape" (*ibid.*, vi.); (28) "On Congenital Malformation and Heredity" (*ibid.*); (29) "Researches on the Maturation of the Ovum" (*ibid.*); (30) "Certain Malformations in Fishes" (*ibid.*); (31) "Investigations in Artificial Teratogeny" (*ibid.*, vii.); "Extra Cusps on Human Teeth" (*Anat. Anzeiger*, vol. ii.); (33) "Congenital Deficiency of Thumb" (*ibid.*, iii.); (34) "Malformations of the Face" (*ibid.*, iv.); (35) "Musculus sternalis" (*ibid.*); (36) "The Human Skull" (*Birmingham Med. Review*, vol. xviii.); (37) "Hermaphroditism" (*ibid.*, xx.); (38) "Development of Intermaxillary Bone" (*ibid.*, xxv.); (39) "A Manual of Surface-Anatomy" (London, H. K. Lewis, 1888); (40) "The Proportions of the Human Body" (London: Baillière, Tindall, and Cox, 1892).

*Supplementary Certificate.*—"On the Myology of the Pneucephalous Fœtus" (*Journ. of Anat. and Physiol.*, vol. xxvii.,

p. 348); "On Certain Early Malformations of the Embryo" (*ibid.*, p. 436); "On some Conditions related to Double Monstrosity" (*ibid.*, vol. xviii., p. 25); "The Effects of Electricity and Magnetism on Development" (*ibid.*, vol. xxix., p. 346); "On the Myology of *Dolichotis Patagonica* and *Dasyprocta Isthmica*" (*ibid.*, vol. xxxi., p. 343); "On some Points in Comparative Myological Nomenclature" (*ibid.*, vol. xxxi., p. 522); "On the Anatomy of *Macropus Rufus*" (*ibid.*, vol. xxxii., p. 119); "On a Specimen of Bifid Clitoris" (*Proc. Anat. Soc. Gt. Brit.*, 1893, vol. xxii.); "On the Cusps of the Aortic Pulmonary Orifices" (*ibid.*, 1895, vol. iv.); "On the Double Malformations amongst Fishes" (*Proc. Zool. Soc.*, 1895, p. 423); "On the Myology of the Terrestrial Carnivora.—Part I., Muscles of the Head, Neck and Fore-Limb" (*ibid.*, 1897, p. 370); "On the Physical Characters of the Boys at King Edward's Schools, Birmingham, and at certain other Public Schools" (*Proc. Birm. Phil. Soc.*, 1892, 216); "On the Physical Characters of a Group of Birmingham Pupil Teachers" (*ibid.*, 1895, p. 97); "Note on a Roman Pottery near Mancetter" (*Proc. Soc. Antiq.*, vol. xvi., p. 404); "On the Prehistoric Implements of Warwickshire and Worcestershire" (*Birm. Arch. Soc. Proc.*, 1897); "Life in Early Britain: being an Account of the Early Inhabitants of this Island and the Memorials which they have left behind them" (London: D. Nutt, 1897).

## *WORK OF THE SMITHSONIAN INSTITUTION IN 1897–8.*

THE report of Prof. S. P. Langley, Secretary of the Smithsonian Institution, upon the operations of the Institution for the year ending June 30, 1898, reached us a few weeks ago. It refers to the work of the U.S. National Museum, the Bureau of American Ethnology, the International Exchanges, the National Zoological Park, and the Astrophysical Observatory, all of which are under the direction of the Institution.

Map showing distribution of Correspondents of the Smithsonian International Exchange Service.

The promotion of original research has always been one of the principal functions of the Institution. Investigations in the anthropological, biological and geological divisions of science have been extensively carried on through the departments of the National Museum, and in the Bureau of American Ethnology there have also been special inquiries into Indian customs and languages. These lines of research being well represented by its bureaus, it has remained for the Institution proper to devote its energies more especially to some of the physical sciences.

Prof. Langley has carried on researches in the solar spectrum, which, by the active assistance of Mr. C. G. Abbot, have produced important results shortly to be published. He has not wholly discontinued the studies which he has made in regard to aërodromic experiments, and it is perhaps not improper that he should state that these have attracted the attention of other departments so far that during the war with Spain a commission was directed by the Secretaries of War and the Navy to inquire into them with a view of their possible utility in war.

In connection with the Hodgkins fund, several grants have been made for scientific investigations. Mr. A. Lawrence Rotch, of the Blue Hill Meteorological Observatory, Readville, Mass., has received grants for experiments with automatic kites, for determining, by means of self-recording instruments, meteorological data in atmospheric strata inaccessible except by some mechanical method of exploring the atmosphere.

A grant of 500 dollars has been made to Prof. William Hallock, of Columbia University, for an investigation having for its object the complete analysis of a particle of air under the influence of articulate sounds.

A final grant of 250 dollars has been made to Drs. Lummer and Pringsheim, of the Physical Institute of the University of Berlin. The investigation begun by them, in 1893, to determine the ratio of the specific heats, at constant pressure and volume, for air, oxygen, carbon dioxide and hydrogen has now so far progressed that the memoir submitted by Drs. Lummer and Pringsheim, noting the results already attained by them, has been published by the Institution in the Smithsonian "Contributions to Knowledge."

An additional grant has been made to Mr. E. C. C. Baly, of University College, London, to enable him to continue his research upon the decomposition of the atmosphere by electricity and upon the ozonising of mercury.

A grant of 250 dollars has been made to Prof. Arthur G. Webster, of Clark University, Worcester, Mass., for the continuation of a research on the properties of air in connection with the propagation of sound, special effort being directed to the securing of data relating to the influence of the viscosity of air on expiring or vanishing sounds. An instrument devised by Prof. Webster for use in this investigation gives the physical measure of sound, not only when constant, but when rapidly varying. It is expected that this research will furnish results of high practical value in connection with the question of the acoustics of auditoriums, and will contribute information upon points that have not heretofore been satisfactorily investigated.

The operations of the International Exchange Service continue to extend. In 1887 this branch of the Institution sent out 71 tons of documents, and had 2165 correspondents in the United States and 7396 foreign correspondents; during the year covered by the present report it transmitted 151 tons, and had 6915 correspondents at home and 22,543 abroad distributed among 93 countries.

Of the total number—29,458—of correspondents, 12,698 are libraries and 16,760 are individuals. There is no part of the Smithsonian Institution which more efficiently carries out the large purpose of its founder, to diffuse knowledge among men, and it is through this, as much as through any other branch, that its name is known throughout the world.

Appended to the report is a map of the world, a reduction of which accompanies this summary, showing the distribution of the correspondents of the Exchange Service.

## NOTES.

THE Bakerian Lecture of the Royal Society will be delivered next Thursday, May 18. The subject is "The Crystalline Structure of Metals," by Prof. Ewing, F.R.S., and Mr. W. Rosenhain.

A DINNER of the Royal Institute of Public Health will be held at the Hotel Cecil on June 7 to meet Lord Lister, P.R.S., who will be presented with the Harben gold medal, and other distinguished guests, who will receive the Honorary Fellowship of the Institute.

THE Council of the Royal Geographical Society has awarded the founder's gold medal for this year to Captain Binger, who in the years 1887-89 carried out an extensive series of explorations in the vast area included in the bend of the Niger. The patron's medal has been awarded to M. Foureau for his explorations in the Sahara during the last twelve years. The Murchison award has been given to Mr. Albert Armitage for his valuable scientific observations made during the Jackson-Harmsworth Arctic expeditions; the Gill memorial to the Hon. David Carnegie for his journey across the Western Australian desert; the Cuthbert Peek grant to Dr. Nathorst for his important scientific exploration of the Spitsbergen Islands and the seas between Spitsbergen and Greenland; the Back grant to Captain Sykes for his three journeys through Persia, during which he has made important corrections and additions to the map of that country, and done much to clear up the geography of Marco Polo. These honours will be awarded at the anniversary meeting of the Society on June 5, and at the same time the American Ambassador will present to Sir John Murray the gold medal of the American Geographical Society for his contributions to scientific geography.

THE Duke of the Abruzzi has left Rome for Turin, whence he will start on his journey to the Arctic regions.

A LECTURE on "London Fog and Smoke," delivered by the Hon. F. A. Rollo Russell at the Building Trades Exhibition, is published in the *Public Health Engineer* of May 4. From the tables given it appears that during the five months November 1898 to March of the present year, London had rather less than half the amount of sunshine of inland stations, and little more than one-third of the sunshine of the stations on the south coast —all the stations with which comparison was made being within a hundred miles of the metropolis. Mr. Russell thinks that drastic measures should be taken to reduce the smoke nuisance from which London suffers. Apparatus conforming to certain stipulations are now enforced upon owners of house property by the local authorities, and there is no reason why similar rules for the public advantage should not be imposed upon builders and owners in relation to the consumption of fuel. Mr. Russell remarks in conclusion: "If any serious difficulty presents itself in bringing into practice the suggested taxes and remissions, the same principle of compulsion which is adopted for drainage, sanitary appliances, and building materials, might be put into force for the sake of atmospheric purity. There is nothing more important for the welfare of the race than good air, and we know that largely owing to the want of it, the populations of the central parts of our big towns decline and perish, unless continually recruited from the country. And thousands are ever flocking from country to town. Only by a return to the countiy, or by great improvements in the conditions of urban life, can the nation maintain its prosperity."

THE annual conversazione of the Society of Arts will take place at the Natural History Museum, South Kensington, on Tuesday, June 20.

NEWS has reached us of the death of Mr. Mariano de la Bárcena, director of the Central Meteorological Observatory, Mexico.

THE fourth annual congress of the South-Eastern Union of Scientific Societies will be held in the Mathematical School, Rochester, on May 25-27, under the presidency of Prof. G. S. Boulger.

ON Tuesday next, May 16, Prof. W. J. Sollas, F.R.S., will deliver the first of a course of three lectures at the Royal Institution on "Recent Advances in Geology"; and on Thursday, May 25, Prof. L. C. Miall, F.R.S., will begin a course of two lectures on "Water Weeds."

REFERRING to the recent celebration of the centenary of Spallanzani, the Rome correspondent of the *Lancet* says:—Nature study, up to its most refined developments in clinical observation and research, was largely represented at Scandiano, where the great naturalist, physiologist, and scholar, Lazzaro Spallanzani, died one hundred years ago. Prof. Todaro (Rome), Prof. Mosso (Turin), Prof. Bertolini (Bologna), Prof. Pavesi (Pavia), and many others hardly less distinguished, met to do honour to his memory and to inaugurate the *gabinetti scientifici* erected in the neighbouring Reggio Emilia to continue and commemorate his work. The Minister of Public Instruction was represented by Moleschott's successor in the Roman chair of Physiology, Prof. Luciani, whose speech at the tomb of the hero of the day was in all respects worthy of his reputation.

THE first statutory general meeting of the National Association for the Prevention of Consumption and other Forms of Tuberculosis, of which the Prince of Wales is president, was held on Thursday last. The Association has made much progress, no less than 1252 members having been enrolled. The members of the Council include Sir W. Broadbent, Sir J. Blyth, Sir G. T. Brown, Sir J. Crichton Browne, Sir J. T. Brunner, M.P., Sir A. Christison, Sir Ernest Clarke, Prof. Corfield, Sir R. G. Wyndham Herbert, Prof. McFadyean, Sir H. Maxwell, and Sir Frederick Wills. Dr. Clifford Allbutt, in moving a vote of thanks to the organising committee, said that since the last generation England had been losing the leading position which she had attained in preventive medicine, and he suggested the advisability of chairs of comparative pathology being established. Dr. Church, the president of the Royal College of Physicians, in seconding the motion, pointed out that the movement against tuberculosis was not a matter in which the medical profession alone were interested, or in which they should take a leading part.

THE short paper on "Aetheric Telegraphy" read before the Society of Arts on May 3, by Mr. W. H. Preece, C.B., F.R.S., and printed in the current number of the Society's *Journal*, constitutes an instructive statement as to what has been accomplished in wireless telegraphy by Mr. Marconi and before him, and what can be expected from it in the near future. As to the practical value of wireless telegraphy at present, Mr. Preece remarks: "There can be no question of the commercial value of the system for lightships, isolated lighthouses, shipping generally, and for [naval and military purposes, but for commercial uses, such as telegraphic communication with France, the system is at present nowhere. A single cable to France could transmit 2500 words a minute without any difficulty. A single Marconi circuit could not transmit more than twenty words a minute."

IN connection with the subject of electrical signalling without intervening wires, an interesting letter by Prof. D. E. Hughes appears in the current number of the *Electrician*. Prof. Hughes describes experiments made by him in 1879, and witnessed by several distinguished Fellows of the Royal Society, on

phenomena produced by ether waves, and the action of the waves on a microphonic coherer across intervening space. Electric waves as such were then unknown to science, so that Prof. Hughes apparently anticipated Hertz's brilliant discoveries. He also conducted experiments on wireless signalling on a considerable scale. In 1879, 1880, and 1888, he demonstrated to several eminent men of science his experiments upon aerial transmission of signals by means of the extra current produced from a small coil, and received upon a semi-metallic microphone, the results being heard upon a telephone in connection with the receiving microphone. The transmitter and receiver were in different rooms, about 60 feet apart, but signals were also received up to a distance of 500 yards, and an attempt was made to signal between houses a mile apart. Prof. Hughes considered that the results were produced by aërial electric waves; and it was because he was unable to demonstrate the actual existence of these waves that his investigations were never published.

A GOOD instance of the manner in which "sea-serpent" myths originate is afforded by certain paragraphs which have recently appeared in the Australian papers. In its issue of February 23 the Melbourne *Argus* announced the discovery at Suwanaw Island, by the officer of a local steamer, of the remains of a sea-monster that had been stranded there some two months previously. The creature was said to be in such a bad condition that collecting its remains was a most trying task; but "two heads, the two backbones, and part of the ribs" were secured. It was stated that there was "but one body, which had a double spine, and two distinct heads"; while the approximate weight of the animal was estimated at not less than 70 tons, and its length fully 60 feet! In the issue of the following day the skulls were said to be about 3 feet long, and to carry a pair of tusks at the tip of the lower jaw. On March 2 the same paper published an announcement that Mr. E. Waite, of the Australian Museum, had identified the remains as those of a "Zithoid"—obviously a misprint for "Ziphioid." It would thus appear that the alleged double-headed monster of 70 tons weight and 60 feet length was based on two carcases of one of the species of Beaked Whales which are of such comparatively common occurrence on the Australian coasts, and the largest of which is not known to exceed 30 feet in length!

AT the last meeting of the Anatomical Society of Great Britain and Ireland, Dr. Elliot Smith settled a point in the comparative morphology of the brain, which at one time was the subject of a heated controversy between Huxley and Owen. In 1861, it may be remembered, Owen maintained that the *calcar avis* and the calcarine fissure which causes it, were characters peculiar to the brain of man; a statement which Huxley showed to be untrue, the formations being well-marked in all Primate brains. Dr. Elliot Smith has reached the further generalisation that the *calcar avis* is a character shown by all mammalian brains, with the possible exception of the Prototherian. He identifies, and the reasons for this identification do not seem capable of refutation, the calcarine fissure of the Primate brain with the splenial fissure of the brain of other mammals. This generalisation will materially assist in homologising the Primate and Unguiculate *pallium*.

IN a paper on "The Western Interior Coal-field of America," by Mr. H. Foster Bain, read at a recent meeting of the North of England Institute of Mining and Mechanical Engineers, the author refers to the estimated area of the coal-fields of the United States as being from 200,000 to 300,000 square miles. In this estimate tracts of Mesozoic as well as Carboniferous coal-bearing strata are included. The Western Interior coal-field occupies a portion of the western half of the Mississippi valley, and is the third in point of production in the United States. Its yield in 1897 was over thirteen million tons. The strata are all grouped as Carboniferous, although some of the higher portions have been regarded as Permo-Carboniferous. Correlations based on fossil evidence are said to be of doubtful value, as the common fossil of the upper strata occur well down in the lower beds. With regard to the coal-seams, all grades from semi-anthracite to free-burning non-coking coal occur, including gas-coal, cannel, and coking-coals.

THE detailed petrographical description of some rock-specimens from Ceylon forms the subject of an interesting paper, by Herr Max Diersche, in the *Jahrbüch der k. k. geol. Reichsanstalt*, Bd. xlviii. Hft. 2 (Wien, 1898). The work is based on material collected by Prof. F. Zirkel during the winter of 1894, and the rock-types described include normal granulite, pyroxene-granulite, gneiss, granite, limestone, and quartzite. An interesting section is devoted to a description of the plumbago of Ragedara and its inclusions. The author remarks on the peculiar occurrence of the graphite at this locality in the form of ramifying veins of varying thickness, sharply marked off at the margins from the surrounding matrix of granulite and pyroxene-granulite. The peculiar mineral and rock inclusions which occur in the graphite veins are dealt with at length, and the paper concludes with a brief discussion of some of the theories that have been brought forward to account for the origin of the graphite. This number of the *Jahrbüch* contains also a geological description of the southern part of the Karwendel Alps, by Herrn Ampferer and Hammer. The region comprised is situated immediately to the north of the Inn valley in the neighbourhood of Innsbruck, and is one which, from its complex relations of structure and facies, offers many difficult problems for geological elucidation. But the authors, with limited time at their disposal, have dealt in a comprehensive manner with the stratigraphy and tectonic relations of this complicated area; and their paper, illustrated by numerous diagrams and accompanied by a coloured geological map, should prove of value to students of Alpine geology.

ANOTHER important contribution to our knowledge of the geology of the Alps appears in the *Verhandlungen* of the above institution (December 1898), where Dr. E. Shellwien records the discovery of a typical marine Permo-Carboniferous fauna in the neighbourhood of Neumarktl, in the Eastern Alps. This occurs at the horizon of the light *Fusulina*-limestone of the Carnic Alps, and there is evidence that in this region there has been uninterrupted deposition from the middle of the Upper Carboniferous into the Lower Permian. The author is led to regard this Permo-Carboniferous limestone as the equivalent of the Cusel beds of Germany. The fauna includes new and interesting forms, and among the Brachiopoda some remarkable types are found to occur. Besides representatives of the genera *Scacchinella* and *Meekella*, a new genus, *Tegulifera*, is present in abundance. It is characterised by a peculiar mode of growth of the larger valve, the lateral margins of which overlap the smaller valve, and, by their continued growth, ultimately envelop the latter completely. The discovery of this comparatively rich fauna corroborates in the fullest manner the views for some time held by Stache regarding the true age of the upper *Fusulina*-limestone stage in the Carnic and Julian Alps.

WE have received a copy of the Second Annual Report of the Geological Commission of the Cape of Good Hope for 1897, and published in 1898. This contains a first instalment of the geological map, neatly printed in colours, and including great part of the Colony eastwards to Cape Infanta and Ladismith, and northwards to Cape Columbine and Laingsburg. The map, which is on a scale of about an inch to 12 miles, is the work of Messrs. A. W. Rogers and E. H. L. Schwarz; and it is accom-

panied by sections showing the flexured structure of the country. A well-deserved tribute is paid to the previous labours of Andrew Geddes Bain and E. J. Dunn. The oldest rocks, known as the Malmesbury Beds, comprise non-fossiliferous slates, mica-schists and quartzites, with intrusive granite. A great unconformity exists between these rocks and the overlying Table Mountain Sandstone. That series again is non-fossiliferous, but it is succeeded by the Bokkeveld Beds, shales and sandstones which yield genera characteristic of the Devonian period. The overlying Witteberg Beds, mainly quartzites, have yielded but a few obscure plant-remains; while still higher in the sequence comes the Dwyka Conglomerate, which may be of subaërial origin; and above it there is a series of shales and sandstones, known as the Ecca Beds, which have yielded occasional plant-remains. This great series overlying the Bokkeveld Beds is usually regarded as of Carboniferous age. Attention is given in the Report to the superficial deposits, and to the economic products of the regions examined. The work of the Survey is superintended by Prof. G. S. Corstorphine.

THE Meteorological Section of the Hydrographical Committee of St. Petersburg has published, as a supplement to vol. xix. of the *Hydrographical Journal*, a useful collection of tables referring to lighthouses and stations on the shores of the Black Sea and Sea of Azov, and of the Caspian, Baltic and White Seas. The observations were made in the years 1890–6, and give for each month and year particulars relating to the level of the water, the direction and velocity of wind, and the temperature of the sea surface. The text also contains details of the various stations, the times of observation, &c.

IN the *Verhandlungen* for 1898 of the Natural History Society for the Prussian Rhineland, &c., Dr. Geisenheyner commences an exhaustive account of the Rhenish Polypodiaceæ. The present instalment is entirely devoted to the three species *Blechnum spicant*, *Scolopendrium vulgare*, and *Ceterach officinarum*; numerous forms, varieties, and sports being described in great detail.

THE first and second Hefts of vol. xxvii. of Engler's *Botanische Jahrbücher* are chiefly devoted to instalments, by various authors, of the editor's contributions to the Flora of Africa. There are, in addition, papers by Dietel and Neger on the Uredineæ of Chile; by Pilger, on South American grasses; and by Ule, on the Sphagnaceæ of Brazil.

MR. A. H. TROW reprints from the *Annals of Botany* a paper containing an elaborate account of researches on a Welsh variety of *Achlya americana*, undertaken with the special object of determining the nature of the chromosome-like body in the centre of the nucleus. His conclusion is that the nucleus is bounded by a nuclear membrane, and possesses a central body of spongy texture, which contains chromatin and nucleolar matter, but is neither a nucleole nor a chromosome. He thinks it probable that the reducing divisions in the different groups of plants are not all homologous. There is a true homology in the Muscineæ, Vascular Cryptogams, and Spermaphytes; while in the Thallophytes there are apparently two types of reducing division which are not homologous.

WE have received (in two parts) an exhaustive account of the indigenous native drugs of Australia, by Mr. J. H. Maiden, Government Botanist, issued by the Department of Agriculture, Sydney. It would appear, from Mr. Maiden's opening remarks, that Queensland is by far the richest of the Australian Colonies in native medicinal plants; but the great majority of these are common to India and the Eastern Archipelago. In New South Wales the number of really useful native drugs is very small. In contrast to the natives of India, the Australian aborigines have but very little knowledge of the medicinal properties of their native plants. In addition to a portion of this same paper, the *Agricultural Gazette of New South Wales* for February 1897 contains also the commencement of a paper by Mr. Maiden on the native food-plants of Australia, as well as a number of others by various writers on the cultivation of fruits and other food-plants, and on the breeding of live-stock, of interest to the colonists.

As already announced, MM. Georges Carré and C. Naud have commenced the publication of a physical and a biological series of brochures, under the title of *Scientia*. The third volume of the biological series, "Les fonctions rénales," by Prof. H. Frenkel, has just been published.

*Pearson's Magazine* for May has an interesting article, by Sir Clements Markham, illustrated by several instructive maps, on the parts of the earth which remain to be explored. The same number contains a short account of Mr. Nikola Tesla's experiments with currents of high potential and high frequency.

THE second part of Mr. M. M. Pattison Muir's "Course of Practical Chemistry" has just been published by Messrs. Longmans, Green, and Co. The first part appeared in 1895, and a third part has yet to be published in order to complete the work. We propose to review Mr. Muir's systematic course of laboratory work when the three volumes are available.

PROF. MAURICE FITZGERALD writes to say that in his article on "The Flight of Birds," in NATURE of April 27, he inadvertently attributed to Lord Kelvin the explanation of the way in which birds may utilise varying air currents for soaring instead of to Lord Rayleigh, who published it in NATURE on April 5, 1883 (vol. xxvii. p. 534).

THE relationships between organic and inorganic chemistry were discussed by Dr. H. N. Stokes in an address recently delivered before the Chemical Society of Washington, and printed in *Science*. Incidentally Dr. Stokes remarks: "The aim of physical chemistry will have been accomplished when it has established a mathematical equation which, by proper substitution, will enable us to predict the nature of every possible chemical system or reaction, and the properties, physical and chemical, of every possible element or compound."

MR. J. G. FRAZER concludes, in the current number of *The Fortnightly Review*, a contribution commenced in the April issue on "The Origin of Totemism." The general explanation of totemism to which the *Intichiuma* ceremonies, which are described in "The Native Tribes of Central Australia," by Messrs. Spencer and Gillen, and discussed in the first part of the paper, seem to point is that it is primarily an organised and co-operative system of magic designed to secure for the members of the community, on the one hand, a plentiful supply of all the commodities of which they stand in need, and, on the other hand, immunity from all the perils and dangers to which man is exposed in his struggle with nature. Such an explanation is shown to be both simple and natural, and in entire conformity with the practical needs as well as the modes of thought of savage man. Referring to the investigations made by Messrs. Spencer and Gillen, Mr. Frazer, while admitting that it may be premature to say their work has finally solved the problem of totemism, says the researches at least point to a solution more complete and satisfactory than any that has hitherto been offered.

PROF. HERDMAN, F.R.S., with the assistance of Mr. Andrew Scott and Mr. James Johnstone, has drawn up in the form of a brochure of eighty-eight pages, the report for 1898 of the Lancashire sea-fisheries laboratory at University College, Liverpool, and the sea-fish hatchery at Piel. The report contains papers by Mr. Andrew Scott on fish-hatching work at Piel, observations on the occurrence and habits of *Leptocephalus*, observations on

the habits and food of young fishes, plankton work and experiments with weighted drift and bottles. Mr. James Johnstone writes on the spawning of the mussel (*Mytilus edulis*); Prof. Herdman on sea-fish hatching, and on oysters and disease: Mr. Charles A. Kohn on occurrence of iron and copper in oysters; Mr. R. S. Ascroft on mussels and mudbanks; and Messrs. F. W. Keeble and F. W. Gamble present a brief report on the physiology of colour-change in *Hippolyte* and other marine crustacea. This is the first complete year of Mr. Scott's work at the Piel hatchery, and of Mr. Johnstone's work at the laboratory. The laboratory attached to the hatchery is open, under certain conditions, to the use of *bona-fide* students and others desirous of prosecuting research. A glance at the above list of papers will show the variety and extent of the investigations that were undertaken last year.

THE scientific activity of the Société de Physique et d'Histoire naturelle de Genève during 1898 is evidenced by the survey of papers published in the *Archives* of the Society, given by Prof. Albert Rilliet in his presidential report just issued. In mathematics and astronomy M. René de Saussure contributed the results of a geometrical study of the movement of fluids, Prof. Gautier computations referring to the return of Tempel's periodic comet, and M. Pidoux observations of an occultation of Antares by the moon. In physics and chemistry M. Dumont gave an account of researches on the magnetic properties of iron and nickel, MM. Dutoit and Friderich described a method of indirectly calculating critical pressure, Prof. Amé Pictet gave an account of further researches on the synthesis of nicotine, and Prof. Soret described his investigations of the causes which produce left- and right-handed crystals in salts active in the crystalline state and inactive in solution. Although no positive results were obtained, the work is important from a statistical point of view. Among the subjects of papers in zoology, physiology, and medicine, were the development of butterflies, by M. Arnold Pictet; and the place of origin of vaso-motor nerves, and effects of currents of high frequency upon the frog, by Dr. Batelli. In botany, a paper by Mlle. Goldfluss on the functions of certain cells was communicated by Prof. Chodat. In physical geology, M. Ed. Sarasin described the records obtained by a limnimeter established at Lucerne during five months in 1897. The records show three distinct periods of oscillation. The results of a detailed inquiry into the constitution of Mont Blanc are given by Prof. Duparc in an important memoir just published by the Society. Finally, mention may be made of a paper by MM. Etienne Ritter and Delebecque on the lakes of the Pyrenees. A number of other papers were read before the Society during 1898, but those here mentioned will be sufficient to show the valuable character of the work accomplished.

THE additions to the Zoological Society's Gardens during the past week include two Mozambique Monkeys (*Cercopithecus pygerythrus*), a Sykes's Monkey (*Cercopithecus albigularis*) from East Africa, presented by Mr. Boyd Alexander; a Macaque Monkey (*Macacus cynomolgus*) from India, presented by Mrs. Herbert Peel; a Slow Loris (*Nycticebus tardigradus*) from Malacca, presented by Mr. W. H. St. Quintin; two Squirrel-like Phalangers (*Petaurus sciureus*, ♂ ♀) from Australia, presented by Mr. A. V. Willcox; four Dormouse Phalangers (*Dromicia nana*) from Tasmania, presented by Dr. McDougall; a Greater Black-backed Gull (*Larus marinus*), a Lesser Black-backed Gull (*Larus fuscus*), European, presented by the Rev. W. B. Tracy; a Drill (*Cynocephalus leucophoeus*), a Kusimanse (*Crossarchus obscurus*), a Pardine Genet (*Genetta pardina*), a Home's Cinixys (*Cynixys homeana*), a Derbian Sternothere (*Sternothoerus derbianus*) from West Africa, a Bell's Cinixys (*Cinixys belliana*) from Tropical Africa, a Common Zebra (*Equus zebra*, ♂) from South Africa, a Grecian Ibex (*Capra oegagrus*, ♂), South-east European, a Two-wattled Cassowary (*Casuarius bicarunculatus*) from the Aroo Islands, deposited; two Larger Tree Ducks (*Dendrocygna major*) from India, purchased; a Mouflon (*Ovis musinon*, ♀) born in the Gardens.

## OUR ASTRONOMICAL COLUMN.

COMET 1899 *a* (SWIFT).—This comet is now well situated for observation in the early morning, and has been frequently seen during the past week. Passing rapidly to the north-west, it will rise earlier every morning, and opportunities will be afforded of obtaining both photographic and visual records of its form and spectrum. The positions predicted by the ephemeris are so nearly correct that there is no possibility of mistaking the comet. As seen on several mornings at the Solar Physics Observatory, South Kensington, it appears to the unaided eye as bright as a star of the fourth magnitude, and, though possessing no tail, is sufficiently unlike a star in appearance to attract notice. With a telescope it is seen to consist of an irregular nucleus about 1′ in diameter, surrounded by a much fainter nebulous mass some 10′ in diameter. Photographs of the spectrum have been obtained showing six bands between D and H, the origins of which have not yet been deduced.

During the week the comet will pass from Pegasus into Lacerta, through a region devoid of conspicuous stars; but on the 17th it will be about 3° west of the second magnitude star o Andromedæ.

The following ephemeris is by Herr H. Kreutz in *Astr. Nach.* (Bd. 149, No. 3556).

*Ephemeris for 12h. Berlin Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ | Br. |
|---|---|---|---|
| May 11 | 23 26 28 | +33 12·7 | 1·66 |
| 12 | 20 48 | 34 33·1 | |
| 13 | 14 41 | 35 36·8 | 1·68 |
| 14 | 8 2 | 37 23·9 | |
| 15 | 23 0 46 | 38 54·2 | 1·71 |
| 16 | 22 52 48 | 40 27·8 | |
| 17 | 44 2 | 42 4·2 | 1·74 |
| 18 | 22 34 21 | +43 42·9 | |

TEMPEL'S COMET (1873 II.).—The following ephemeris for this comet is by M. L. Schulhof in *Astr. Nach.* (Bd. 149, No. 3554):—

*Ephemeris for 12h. Paris Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ ″ | Br. |
|---|---|---|---|
| May 11 | 19 0 46·1 | − 4 15 3 | |
| 12 | 2 25·8 | 4 11 42 | 0·592 |
| 13 | 4 5·2 | 4 8 30 | |
| 14 | 5 44·2 | 4 5 29 | |
| 15 | 7 22·7 | 4 2 38 | |
| 16 | 9 0·9 | 3 59 59 | 0·673 |
| 17 | 10 38·7 | 3 57 31 | |
| 18 | 19 12 16·1 | − 3 55 17 | |

The comet is moving slowly to the north-east, passing from Scutum Sobieski into the southern part of Aquila, being about 10° S.W. of α Aquilæ on the 18th.

A telegram just received from Kiel announces the first observation of this comet during this apparition, by Prof. Perrine at the Lick Observatory. Its position as measured was

R.A. 18h. 52m. 58s. }
Decl. − 4° 32′ 19″ } 1899 May 6, 13h. 40·5m. Lick Mean Time, and it is described as being faint.

The close agreement of these numbers with the computed data given in the ephemeris renders any revision of the latter unnecessary.

## PROGRESS IN THE IRON AND STEEL INDUSTRIES.[1]

THE announcement that Her Majesty the Queen will be graciously pleased to accept the Bessemer Medal for 1899, in commemoration of the progress made in the iron and steel industries during her reign, will be received with enthusiasm throughout the Empire. What the progress has been it will be

[1] Abstract of the presidential address to the Iron and Steel Institute, by Prof. Sir W. Roberts-Austen, K.C.B., D.C.L., F.R.S., delivered before the members of the Institute on May 4.

my privilege to indicate in this Address; for your last President of the century, in bidding it a respectful farewell, must offer the best retrospective tribute he can to the grandest industry in the world's history.

This address will, therefore, be mainly devoted to the consideration of British efforts in connection with iron and steel. I shall hope on another occasion to pay homage to the services rendered in other countries to our branch of metallurgy, but in view of our autumn meeting last year at Stockholm, I cannot proceed further without making a brief reference to Sweden. To her scientific men our debt is great and of long standing, for we have profited by their labours from the eighteenth century until now. We appreciated the interest in our proceedings which was shown by the presence of His Majesty the King and the Royal Princes at our meetings in the Riddarhus. The gracious kindness of His Majesty during the magnificent reception at his palace of Drottningholm will never be forgotten by those of us who were present. The spontaneous warmth of our reception by the Swedish people also touched us deeply, and the memories of our visit will be handed down as traditions to future members of our Institute, who, in the days to come, will, we trust, again seek the aid of Sweden by supplementing the ores of our own possessions with those from within the Arctic circle.

From the technical point of view, as the eighteenth century closed, a new era in the metallurgy of iron had already begun. Abraham Darby had successfully introduced the use of coke in the blast-furnace; James Watt had, by his powerful engines, much facilitated the production of blast, and had greatly stimulated the out-turn of pig iron. Nevertheless, the total annual production of pig iron in the year 1799 did not exceed some 150,000 tons. From the scientific point of view the situation was one of singular interest. The early writers held that good and bad qualities might be inherent in the iron itself. Pliny points out how greatly the properties of iron depend upon its treatment, but he thought that as for the kinds of iron, they were many and all were distinct, and the first difference arises from the diversity of the soil and climate where the mines are found. But Pliny's view survived far into the present century, and evidence of it lingered in the effective and graceful speech in which the Member for Merthyr proposed a vote of thanks to our first President on the delivery of his inaugural address. Mr. Fothergill said then that "thirty years ago the idea prevailed universally . . . that good iron was to be found in certain localities, and could be procured from no other place; it was found good in one place and bad in another." He adds: "Enlightened progress of the last thirty years has shown that the quality of iron depends upon the alloy with which it is mixed."

Enduring as the old view as to the influence of locality was, an experimental basis for a more accurate one had been established very shortly before the present century began, and some, at least, knew that the properties of iron depended on the presence or absence of certain other elements. This position was clearly established by the great Swedish chemist, Bergman of Upsala, who had shown that carbon is the element to which steel and cast iron owe their distinctive properties. He had initiated the employment of calorimetric methods in determining the properties of iron and steel. He insisted that the real difficulty is to explain how it is that the presence of 0·5 per cent. of carbon in iron enables the metal to be hardened by quenching from a red heat, or, in his own expressive words, *Ceterum quomodo dimidia centesima, plumbaginem efficiens, tantam provocare possit differentiam, nodus est gordius haud facile solvendus.* Bergman, moreover, anticipated the later phases of modern research by claiming that iron is a polymorphic element, and plays the part of many metals. In this early view as to the allotropy of iron it should be remembered that in 1790 our countryman, James Keir, followed him closely by urging, before the Royal Society, that what we now call passive iron "is really a distinct form of iron, the alteration being produced without the least diminution of its metallic splendour or change of colour."

Clouet's celebrated experiment on the carburisation of iron by the diamond followed. Doubts, however, were not finally set at rest until 1815, when Pepys, a working cutler in London, excluded the possibility of the intervention of furnace gas. But, as soon as the present century had well turned, the industrial world was in possession of the fundamental fact that carbon is the element of dominant importance in relation to the metallurgy of iron. Well might Bergman express astonishment at the action of carbon on iron. Startling as the statement may seem, the destinies of England throughout the century, and especially during the latter half of it, have been mainly influenced by the use of steel. Her steel rails seldom contain more than Bergman's half per cent. of carbon. Her ship-plates, on which her strength as a maritime power depends, contain less than half that amount. It is essential that the significance of this fact should be clearly understood. Our national existence has long depended on iron and steel. They have been the source of our wealth, one of the main elements of our strength, one cause of our maritime supremacy. Hardly a step of our progress or an incident of our civilisation has not, in one way or another, been influenced by the properties of iron or steel. It is remarkable that these properties have been determined by the relations subsisting between a mass of iron, itself protean in its nature, and the few tenths per cent. of carbon it contains. These properties are, it is true, modified either by the simultaneous presence of elements other than carbon, or by the thermal or mechanical treatment of the mass. The growth of our knowledge of the facts constitutes a large section of our scientific and industrial history. The question arises—Was our national progress delayed by the unreadiness of the technical world in England to take advantage of the facts that science had established?

If we consider the position from the point of view of two remarkable men who were looking for the dawn of the nineteenth century as we are for that of the twentieth, we shall, I think, be satisfied that our progress received no check from failure of industrial workers to assimilate the teaching of science. These men were Black and Cort. Of the scientific men then living, the greatest chemist was Black, Professor at the University of Edinburgh, whom Lavoisier had generously acknowledged as his master. Black fully recognised the importance of Bergman's work, and on his own part insisted on the importance of what would now be called the change in molecular energy as the physical basis on which the properties of iron and steel depend. Black, moreover, in his public lectures gave a singularly accurate description of the process of decarburising iron called "puddling," and devised by "a Mr. Cort," with the results of whose work Black was soon to become familiar. Considering how recent the knowledge of the meaning of oxidation really was at the time, Black's statements with regard to the theory of puddling are truly remarkable. Later on he furnished the Government with an elaborate report on the quality of the material obtained by puddling. He showed, by such mechanical tests as the experience of the time suggested, the superiority of puddled iron, and pointed out that it was more suitable than foreign iron for the appliances "on which," as he says, "the lives of our seamen and the safety of our ships have hitherto mainly depended."

At the end of the century we are justly proud of our colonial possessions, and are satisfied that the varied applications of iron and steel will enable us to knit together all parts of the empire. At the beginning of the century, Lord Sheffield, in his "Observations on the commerce of the American States," writing in the early days of Cort's process, shows that it would help to make British iron as cheap as the foreign, an event which he considered would be more advantageous to England than the possession of her American colonies. Black died in 1799, Cort survived till 1800, so that as the eighteenth century closed, the most eminent scientific man and the foremost practical metallurgist of the generation stood side by side. To Cort we owe the greatest technical advance the modern world had seen; to Black the recognition of the importance of molecular energy in relation to metallurgical problems.

The production of pig iron in this country also received a great stimulus from the discovery by Mushet about the year 1800, that the large deposits of blackband ironstone could be utilised. The century opened with, in round numbers, an annual production of pig iron not exceeding 200,000 tons, of which less than one-third was converted into bars and other descriptions of wrought iron. The capital invested was under five millions, and employment was furnished for nearly 200,000 people.

Returning to the scientific aspect disclosed at the dawn of the century, the year 1803 was an eventful one for science. Nevertheless, the impulse given to research was not in the most favourable direction for the advancement of metallurgic art. The influence of a small proportion of carbon on iron had been recognised, but the quantitative relation between the iron and the carbon was only considered as bearing on the

nature of the product, and not at all from the point of view of chemical union. When, therefore, in 1803, Claude Louis Berthollet published his "Essai de Statique Chimique," it appeared that the action, of what for the moment I may be permitted to classify as the action of *traces* upon *masses*, was in a fair way to be elucidated for the following reason. Berthollet pointed out that "in comparing the action of bodies on each other which depends on their affinities and mutual proportions, the influence of mass has to be considered." Unfortunately in succeeding years the views of Prout, the courteous opponent of Berthollet, prevailed, mainly through the powerful aid of Dalton, who published also in 1803 his first table of atomic weights. Hence the phenomena which could not be attributed to fixed atomic proportions were set aside and usually neglected. Evidently the action of one-tenth per cent. of carbon on iron could not be explained by the aid of combining weights. The century was more than half over before a school of eminent chemists arose, who did not insist that matter is minutely granular, but in all cases of change of state made calculations on the basis of work done, viewing internal energy as a quantity which should reappear when the system returns to its initial state.

The production of cast iron and bar iron was rapidly increasing, and the suitability of cast iron and bar iron for the construction of bridges became evident to engineers, among whom Telford was pre-eminent. A distinguished professor, a worker in pure science, came, in the person of Dr. Thomas Young, to the aid of the technical worker. The need of studying the mechanical properties of iron and steel was evident, and Young showed that the work done in permanently extending or in compressing iron or steel could be represented by a coefficient, to which he gave the name of the "Modulus of Elasticity." This coefficient has probably rendered more service in the development of the study of the strength of iron and steel than any other which has been determined. It is of great importance, because upon it depends the deflection which a structure will take under strain. Young, evidently with a view to bring home evidence as to the great rigidity of steel, gives in his original paper a quaint illustration. He therein shows that if "Hook's law holds" a hanging rod of steel would have to be 1500 miles long in order that the upper portions of it might be stretched to twice their original length. I would incidentally point out that on the basis of Young's calculation, such a column 1500 miles high, if it were 1 foot $2\frac{4}{10}$ inches in diameter, would represent the output for the past year of Bessemer steel in this country alone. Statements of this kind had such a singular fascination for Sir Henry, that I have permitted myself a brief departure from chronological order in offering this one.

[The President then referred to the patent granted in 1817 to the Rev. Robert Sterling for the "regenerative furnace," and to the work of S. B. Rogers, who introduced "iron bottoms" in the puddling furnace. An interesting fact was mentioned which justified the claim made in the address, that Rogers was the pioneer of the great process afterwards known as the "basic" process of dephosphorisation. Faraday's work on alloys in 1820, and his discovery of "a carburet of iron" in 1822 was then described, and the merits of Neilson's discovery of the "hot blast" in 1828 were fully dealt with. After a brief reference to the work of Thomas Andrews, of Belfast, on the "heat of combination," the President proceeded to review the theories of the action of the blast-furnace, and especially referred to the work done in the year 1846.]

It was pointed out in 1846 that in the blast-furnace there was evidently a kind of tidal ebb and flow in the relations of carbon and of oxygen, resulting sometimes in reduction, and at others in oxidation or carburisation; but the changes were all capable of more or less simple expression if viewed either from the atomic or the dynamic standpoint. As the furnaces grew in dimensions, their flaming tops threw a lurid glare over the country, and, "like the dying sunset kindled through a cleft," revealed the magnitude of the problems involved in blast-furnace practice, which were seen to be disproportionate to their apparent simplicity.

In the first half of the century efforts were directed mainly to obtaining a material—cast iron containing some $3\frac{1}{2}$ per cent. of carbon, and fusible at a temperature readily attained in the blast-furnace. In the second half of the century, while efforts to obtain this fusible material were increased, attention was also directed to removing the carbon, and obtaining a product which had a melting point of 400° C. (720° F.) higher than cast iron. This product was either cast directly into ingot moulds or recarburised to the extent necessary to constitute the various gradations of steel. Sheffield hardly knew steel except as a material to be used for the manufacture of cutlery, for which she had been famous since the time of Chaucer.

It is characteristic of our British methods that special circumstances and needs, mainly arising in connection with the development of the steam engine and railways, revealed the broad principles by which the production of iron must be governed. It was natural, therefore, as time went on, that in the work of successive inventors the guidance of scientific principles became progressively evident as ill-directed efforts were gradually replaced by the results of systematic experiments.

The second half of the century began with events of strange importance. The Great Exhibition revealed our industrial strength to all nations. The official reporter of the metallurgical group states that 2,250,000 tons of pig iron were annually produced in this country, and that its estimated value was 5,400,000*l*. The annual production had risen in fifty years from two hundred thousand tons to over two and a quarter millions. Sheffield produced at the opening of the century 35,000 tons of steel, of which 18,000 tons were cast steel. Messrs. Turton exhibited a single ingot of steel weighing 2688 lbs., but Krupp showed an ingot of double the weight, for our country was only preparing for the great change which was so soon to enable it to lead the steel manufacture of the world.

A noteworthy feature of the Exhibition was the collection of iron ores of this country exhibited by Mr. Blackwell, who subsequently, and most generously, provided funds for their analysis. With reference to this collection, the reporter points out that in this country "the ores are not carried far, except where there is great facility for transport." This is noteworthy, as before the century was much older an important supply of ore was brought from Spain, and in the near future we may even seek a supply for British furnaces from distant parts of our own empire.

The year 1851 was, moreover, an important one for metallurgy in this country, as it saw, by the wisdom of H.R.H. the Prince Consort, the establishment of the institution which developed into the Royal School of Mines. If the projected scheme of instruction had been fully carried out, the establishment of a general system of technical instruction, which the pressure of necessity is slowly forcing upon us, would have been anticipated by forty years.

The year 1856 will be ever memorable in the metallurgical annals of our nation as that in which Bessemer gave the description of his process to the world at the Cheltenham meeting of the British Association. As regards the process itself, we have too lately lost our great countryman, and many of us are too familiar with the details of his labours to be able either to fully estimate its value or to realise the wonder of its results. Let us try to think of the Bessemer process as I believe those at the end of the twentieth century will, whose views range over a wider perspective than we can command. The economic aspect of the question will naturally strike the metallurgists of the twentieth century. They will see that in 1855 the make of steel in Great Britain did not exceed 50,000 tons, and the cost of the steel produced sometimes reached 75*l*. a ton. They will see that thirty years after the publication of Bessemer's paper the production of Bessemer steel rose to 1,570,000 tons, and that ship plates were sold at 6*l*. 10*s*. a ton. It will be noted that before the century closed, the maximum production of Bessemer steel in this country in one year reached 2,140,000 tons. The scientific aspect of the process will, however, excite their widespread interest, for before the end of the twentieth century, metallurgy will be taught in our older universities. It will be seen that, notwithstanding the title of Bessemer's Cheltenham paper, he recognised and insisted on the fact that the intense heat was engendered by the combustion of the elements within the fluid bath. It will be noted in what close relation the purely scientific work of Thomas Andrews of Belfast, on the heat of combination, stands to that of Bessemer, and that another instance is presented of the dependence of industrial work on pure investigation. Bessemer's proposal to employ a mixture of steam and air will not be ridiculed as it has been, for speculation will be rife as to whether he did not hope that the liberated hydrogen might remove sulphur and phosphorus, notwithstanding the feebly exothermic result of the ensuing combination, and in spite of the cooling effect of water vapour. In view of the fact that

endothermic combinations take place at a high temperature, the possible action of hydrogen as a decarburiser will be dwelt upon. Prof. Noel Hartley's papers upon the thermo-chemistry of the Bessemer process will be read with much interest, Surprise will, however, be widely felt that physicists generally of the last half of the nineteenth century did not see in the lovely flames of lilac, amethyst, gold, and russet, or in the "stars suspended in a flying sphere of turbulent light" which come from the converter, an appeal to fully investigate their cause and to study the dynamic problems presented by the intense heat engendered. Why was not the destination ascertained of the 1000 cubic feet of argon which accompanies the air passing through the metal during an ordinary Bessemer 10-ton blow? Why were not more strenuous efforts made to ascertain the effect of the temperature of the bath on the nature of the metal?

It will be felt that, as the eighteenth century had closed with a clear statement as to the true nature of oxidation, the nineteenth century had seen its magnificent application in the Bessemer process.

As regards the work of Mushet, future generations will, I believe, desire to add nothing to the words of the President of this Institution who, in 1875, had the pleasure of awarding the Bessemer Medal to him. Mr. Menelaus then said "that the application of spiegeleisen . . . was one of the most elegant as it certainly was one of the most useful inventions ever made in the whole history of metallurgy."

Attention must now be directed to the great process for the production of steel which involved the use of the "open hearth."

Sir William Siemens' life was one long and ultimately brilliantly successful effort to apply the kinetic theory of gases and the dynamical theory of heat to industrial practice. He was eminently a practical worker; but the depth and accuracy of his scientific knowledge gives him a place near that of all the great atomists from the time of Lucretius to that of our own countrymen, Graham, Joule, Clerk Maxwell, and Kelvin. In many of Siemens' papers, theory and practice are closely blended. In viewing the results of his labours, it will be seen in future ages that confidence in the trustworthy character of steel was finally established by experiments on metal produced in the regenerative furnace of Siemens. Looking back, it is astonishing with what difficulties the use of steel for structural purposes was beset. In 1859 Sir John Hawkshaw was not permitted by the regulations of the Board of Trade to employ steel in the construction of the Charing Cross bridge. Time will not permit me to indicate the efforts which were made to induce the Board of Trade to remove the serious hindrances to the use of steel, which had "rendered the construction of the projected bridge over the Firth of Forth practically impossible." These efforts were not successful until 1877, when a committee, consisting of Sir John Hawkshaw, Colonel Yolland, and Mr. W. H. Barlow, were able to recommend that the employment of steel in engineering structures should be authorised by the Board of Trade. The steel employed was to be "cast steel, or steel made by some process of fusion, subsequently rolled or hammered"; one condition of such recommendation being that "the greatest load which can be brought upon the bridge or structure, added to the weight of the superstructure, should not produce a greater strain in any part than $6\frac{1}{2}$ tons per square inch."

As regards the use of steel for shipbuilding purposes, in the year 1875 Sir Nathaniel Barnaby asked, "What are our prospects of obtaining a material which we can use without such delicate manipulation, and so much fear and trembling?" He partly answered his own question four years later, when he quoted experimental evidence as to "the recent successes" of open-hearth steel. In 1890 he completed the case by pointing out that naval architects now "have a perfectly regular material, stronger and more ductile" than iron, and he speaks of "our lasting debt of gratitude for the birth and training of that true prince, William Siemens." It is hardly necessary to point out that the country owes the excellent materials used in naval architecture mainly to the productions of the regenerative furnace.

In connection with the production of mild steel, the addition of ferro-manganese to the decarburised bath proved to be most effective. We can hardly over-estimate our indebtedness to those whose perseverance ensured the adoption of mild steel for maritime and other purposes. "Looked at from the standpoint of to-day, when thousands of tons of such steel are made weekly without serious anxiety or trouble, it is scarcely possible to realise the anxieties and difficulties of the days when the manufacture of open-hearth steel was being perfected." To no one is our debt greater than to our Vice-President, Mr. James Riley, who bore a large share of the anxieties of the early days, and whose words are those I have just quoted.

With regard to the great modifications which have been effected in the Bessemer and open-hearth processes, reference must be made to that ample source of information, our *Journal*. It must also be consulted for the history of the appliances for heating the blast, with which the names of Cowper and of Whitwell will always be specially connected.

In speaking of Bessemer and Siemens I have been obliged to depart somewhat from strict chronological order. I must now resume it.

In the year 1866 Graham's first paper on the occlusion of gases by metals was published in the *Philosophical Transactions*. Its results have been far-reaching, and will always be ranged with the metallurgical triumphs of the century.

In the year 1869 our Institute was founded. In view of certain aspects of the treatment which inventors had previously received from their industrial brethren and from the country, it will be evident that the time for its formation had fully come. Taking instances almost at random, I may remind you that Dud Dudley was, as he says, "with lawsuits and riots wearied and disabled" in the seventeenth century, and that Henry Cort was neglected and oppressed in the eighteenth. The great invention of iron bottoms in the puddling-furnace made by Rogers was received with ridicule, and he died in poverty. Popular tradition of Sheffield indicates that possession was obtained of Huntsman's secret "by the heartless trick of a rival." Neilson, though he warmly acknowledges the support he received from certain ironmasters, was treated with singular meanness by others. Heath fought single-handed for fifteen years "against a common purse, the accumulation of the wealth which he had created." Even Bessemer's early statements were received with incredulity and contempt. With the formation of our Institute all this is changed: men place the results of their work and experience freely at the disposal of their brethren, and each fresh advance meets with appreciative consideration. "Vigorous moderateness," wrote the late Walter Bagehot, "is the rule of a polity which works by discussion. . . . It was government by discussion that broke the bond of ages and set free the originality of mankind."

[It was then pointed out, that the history of the iron and steel industry since the formation of this Institute was epitomised by the labours of those who had occupied the presidential chair. The President, therefore, gave a brief sketch of the work done either by the successive Presidents of the Institute, or during their respective terms of office.]

The address then continues as follows: This concludes the list of those who have hitherto presided over the Institute, and it will have been evident that from time to time other interests than those connected with iron and steel have been represented by your Presidents. We were reminded of this fact when the Institute first met, now twenty-four years ago, at Manchester, where we are promised a delightful meeting again next autumn. The Bishop of that great city then welcomed us by a quotation from Virgil, which connects the age of iron with the age of gold. The passage runs thus:—

"quo ferrea primum
Desinet ac toto surget gens aurea mundo."

A President of this Institute who has had the privilege to serve in the Mint, in a sense connects the iron and the golden age. I find that during the course of a long official career I have been responsible for the standard fineness of over one hundred and twenty-one millions of gold coin. This sum is so vast, and the anxiety connected with it has been at times so great, that I am not careful to conceal the pride revealed by this reference to it, as it is an exponent of the financial greatness of the nation which created the age of steel. But I value as highly the means of conducting research and the hope of being useful, which was also given me by the Government when I was appointed Professor of Metallurgy at the Royal School of Mines. I have in the discharge of my duties persistently striven to show that what is called applied science is nothing but the application of pure science to particular classes of problems.

I regret that space will not permit me to consider the progress of the century as measured by the work of our Bessemer medallists. I hope, however, as regards the labours of the foreign recipients of the honour, to deal with them next spring.

The metallurgy of America is so closely interwoven with our own, that I must permit myself a brief reference to four men who stand out from the industrial ranks of our kinsmen. These are Alexander Lyman Holley, the Hon. Abram S. Hewitt, John Fritz, and Prof. Henry Marion Howe. All of them are Bessemer medallists.

It may help us to estimate the value of the labours of the four men whose names I have given if we remember that at the present time the United States export about a million tons of iron and steel a year, while twenty years ago they were not exporting any. We may also fairly consider their influence on the rapid development of the United States Navy. It would seem that we, in this country, in the belief in our insular security, had somewhat neglected the art of naval warfare, until Admiral Mahan reminded us of what we had done in the past, and of our possible course in the future, in a series of writings which have done much to convince the two nations, England and America, "that they are in many ways one."

It is time to offer a collective statement of the achievements which have either been actually effected or are in immediate prospect.

There are blast-furnaces which will produce 748 tons of pig iron in twenty-four hours, with a consumption of little over 15·4 cwts. of coke per ton of iron. The gases from blast-furnaces are used, not only as sources of heat, but directly in gas-engines.

There are Bessemer converters which can hold 50 tons of metal, and open-hearth furnaces which will also take 50 tons, while 100-ton furnaces are projected. The open-hearth furnaces are fed with one ton of material in a minute, by the aid of a large spoon worked by an electro-motor. There are gigantic "mixers," capable of holding 200 tons of pig iron, in which, moreover, a certain amount of preliminary purification is effected.

Steel plates are rolled of over 300 feet in area and 2 inches thick. There are girders which justify the belief of Sir Benjamin Baker that a bridge connecting England and France could be built over the Channel in half-mile spans. There are ship-plates which buckle up during a collision, but remain water-tight.

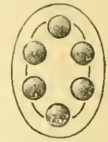
There are steel armour piercing shot which will penetrate a thickness of steel equivalent to over 37 inches of wrought iron. The points of the shot remain intact, although the striking velocities are nearly 2800 feet a second. There are wires which will sustain a load of 170 tons per square inch without fracture. Hadfield, whose labours will, I trust, be continued far into the twentieth century, has given us manganese-steel that will not soften by annealing; while Guillaume has studied the properties of certain nickel steels that will not expand by heat, and others that contract when heated and expand when cool. Nickel, chromium, titanium, and tungsten are freely used alloyed with iron, and the use of vanadium, uranium, molybdenum, and even glucinium, is suggested. There are steel rails which will remain in use seventeen years, and only lose 5 lbs. per yard, though fifty and a half million tons of traffic have passed over them.

Huge ingots are placed in soaking pits and forged direct by 120-ton hammers, or pressed into shape by 14,000-ton presses. With such machinery the name of our late Member of Council, Benjamin Walker, will always be connected.

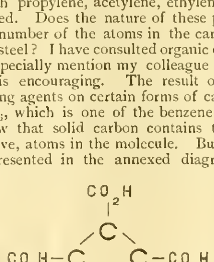
There are steel castings, for parts of ships, that weigh over 35 tons. We electrically rivet and electrically anneal hardened ship-plates that could not otherwise be drilled. Photomicrography, originated by Sorby in 1864, now enables us to study the pathology of steel, and to suggest remedial measures for its treatment. Stead's work in this field is already recognised as classical. Ewing and Rosenhain have, in a beautiful research, recognised quite recently by its aid that the plasticity of a metal is due to "slip" along the cleavage planes of crystals. Osmond also by its aid shows that the entire structure of certain alloys may be changed by heating to so low a temperature as 225° C.

Passing to questions bearing upon molecular activity, we are still confronted with the marvel that a few tenths per cent. of carbon is the main factor in determining the properties of steel. We are, therefore, still repeating the question, "How does the carbon act?" which was raised by Bergman at the end of the eighteenth century. Nevertheless, from the molecular point of view, much may be said in answer to the question. The mystery is in fact lessened now, as it is known that the mode of existence of carbon in iron follows the laws of ordinary saline solutions. Our knowledge is, however, of very recent origin, and we owe mainly to the Alloys Research Committee of the Institution of Mechanical Engineers the development of Matthiessen's view that there is absolute parallelism of the solution of salt in water and carbon in iron.

An ice-floe in a Polar sea contains a small percentage of salt; a red-hot ingot of mild steel holds some two-tenths per cent. of carbon, but both the carbon and the salt are in the state of *solid* solution. If the ice had been cooled below – 18° C., it would entangle a solidified portion of salt water, which was the last part of the mass to remain fluid. So in the steel ingot, when it has cooled to the ordinary temperature, there is a solidified "mother liquor" of carburised iron. We do not as yet know whether carbon is dissolved in fluid iron as carbon or as a carbide. We do know, however, that the presence of 0·5 per cent. of carbon in iron (such an amount as might occur in a steel rail) lowers the melting point of the iron from 1600° C. to 1530° C. This lowering has enabled a calculation to be made, the result of which shows that the number of atoms in a molecule of carbon in *fluid* iron at this temperature is probably *two*. It can be shown that at a temperature of 800° C. the number of atoms in the molecule of carbon dissolved in *solid* iron is, in all probability, *three*. At lower temperatures, the number of atoms is probably more than three. We metallurgists are not accustomed to think in atoms. Let me, therefore, represent such a three-atom molecule thus,  without assuming how much iron is associated with the carbon. Following Bergman's experimental method, but with the interval of more than a century separating his work from ours, we investigate the action of acids on carburised iron with a view to ascertain the nature of the atomic grouping of the carbon.



In explaining this, I may adopt the appended figure. It is most difficult even to attempt to make questions of atomic grouping clear in a paragraph, but the figure will be helpful. To the historian it suggests vivid pages of Italian history, as the six spheres so arranged constitute the arms of the powerful family of Medici. To the chemist it is a precious symbol, and appeals to him as representing the carbon atoms as grouped in the benzene ring. The result of treating carburised iron with various acids is the formation of marsh-gas and more complicated organic compounds, of which propylene, acetylene, ethylene, and naphtha may be mentioned. Does the nature of these products help us to ascertain the number of the atoms in the carbon molecule as it exists in cold steel? I have consulted organic chemists, among whom I would specially mention my colleague Dr. Wynne, and their evidence is encouraging. The result of the action of powerful oxidising agents on certain forms of carbon is mellitic acid, $C_6(CO_2H)_6$, which is one of the benzene series, and this favours the view that solid carbon contains twelve, or some multiple of twelve, atoms in the molecule. But mellitic acid is graphically represented in the annexed diagram, the carbon




atoms being arranged as the six spheres are in the arms of the Medici. The group $CO_2H$ is tacked on to each carbon sphere. From this it may be argued that the molecule of solid carbon consists or one or more carbon "rings." In cold steel, the group of $CO_2H$ may be replaced by the group $Fe_3$, which is broken off by the action of suitable solvents leaving free carbon. Hence the six-atom carbon molecule may exist in steel.

My object is merely to show you how far at the end of the century we have advanced in our knowledge of the mode of action of carbon, and I trust it will be evident that the progress is remarkable. We know that even in solid iron the carbon atom must push and thrust with great vigour, for we can measure the "osmotic pressure" the carbon atom exerts, and, as has just been shown, we can even picture the mode of the atomic grouping in the molecule.

I can only just sum up the evidence as to the occurrence of molecular change in iron. To Gore, and to Barrett, we owe the investigation of the nature of a fact which had long been well known to smiths, that iron on cooling from a bright red heat suddenly emits a glow. We now know that as steel cools down there may be at least six points at which molecular change occurs, accompanied by evolution of heat.

In a series of classical papers of which we are justly proud, for many of them have been communicated to this Institute, our member, Osmond, has shown what is the significance of some of these points, and has won an enduring reputation. We measure and record them photographically as readily as if they were barometric variations. It is known that three points occur in the purest electro-iron yet prepared. Two points are connected with the magnetic permeability of iron. One point at least is due to the power iron has of dissolving carbon. In some cases, two points occur far below a red heat, and appear to be due to the presence of hydrogen. Moreover, the molecular condition of steel cooled from an intense white heat is not the same as that of steel which has just been melted. To carry further the evidence as to the effect of an intense heat on iron in a vacuum is the task I have in prospect during my presidency of the Institute. I may, however, express my agreement with Lockyer's view that the evidence afforded by the atmosphere of the stars shows that our terrestrial iron is a very complex form of matter.

We must not lose sight of those relations of carbon and iron which involve physical equilibrium. Even the astonishing associations of iron and carbonic oxide in the volatile gaseous compound with which the distinguished name of Mond is connected affords a triumph of dynamic chemistry. It is generally supposed that ozone is dissociated at 160° C., but Dewar has devised a beautiful experiment to prove that ozone has two centres of stability, and one of these is near the melting point of platinum. It seems to be the same with the relation of hydrogen and iron. We have recently learned that iron and hydrogen appear to be completely dissociated at 800° C., and yet the same iron heated to some higher temperature, say 1200° C., will still yield hydrogen.

Let us suppose that Black, Cort, and Bergman were with us again, and had reviewed the present state of our knowledge and the work accomplished in the century. Let us also suppose that they could go to Sheffield and see an armour-plate rolled and finished for service, and then, visiting our Institute, hear the best explanation we could offer of all the incidental phenomena they had witnessed. Which would they consider the more advanced, our practice or our theory? They would probably hesitate to tell us, but would offer warm congratulations on the immediate prospect of the establishment of a National Physical Laboratory, in which investigations as to the properties of iron and steel will be continued.

## THE IRON AND STEEL INSTITUTE.

THE annual meeting of the Iron and Steel Institute was held on May 4 and 5 at the Institution of Civil Engineers. The chair was occupied at the beginning of the proceedings by Mr. E. P. Martin, the retiring president. The report of the Council was read by the secretary, Mr. Bennett Brough, and showed that during the year 98 new members had been elected, and that the Institute had maintained its prosperous and satisfactory condition. Sir William Roberts-Austen then took the presidential chair, and delivered an inaugural address, which is printed in an abridged form in another part of this issue. A vote of thanks to the president for his address was proposed by Sir Bernhard Samuelson, seconded by Sir William H. White, and carried by acclamation.

The first paper read was by Mr. H. Bauerman on the Gellivare iron mines, the important mineral region situated in 67° 11′ North latitude and 20° 11′ East longitude. The paper gave a detailed geological description of the mineral deposits, and formed a valuable supplement to previous descriptions of these mines. In the discussion which followed, Mr. W. Whitwell pointed out the importance of this Swedish source of supply in view of the approaching exhaustion of the Spanish deposits, and Mr. H. G. Turner remarked on the similarity of some extensive magnetite deposits in Southern India.

Mr. A. P. Head read a paper on tilting open-hearth furnaces which are coming into use in the United States, and present a substantial advance in metallurgy likely to have far-reaching effects in the future of the relative positions of the Bessemer and open-hearth processes. An interesting discussion followed, in which Mr. Wellman, of Chicago, and Mr. R. M. Daelen, of Düsseldorf, took part.

Prof. Henry Louis then described a dipping needle he had devised for use in exploring for iron ore deposits, which presented decided advantages over the instruments described by Mr. B. H. Brough in 1887, and by Prof. Nordenström last year.

A paper by Prof. J. Wiborgh, of Stockholm, on the use of hot blast in the Bessemer process, was then taken as read. In this the author urged the advantages that would be derived from the use of the hot blast for small converters and for the basic Bessemer process.

The meeting then adjourned until May 5, when a paper by Prof. J. O. Arnold and Mr. A. McWilliam on the diffusion of elements in iron was read. An animated discussion followed, in which Mr. Stead, Mr. Hadfield, Mr. Harbord, Dr. Stansfield and Prof. Louis took part.

A voluminous paper by Baron Jüptner von Jonstorff, on the solution theory of iron, was taken as read. In two previous communications he sought to apply the laws of solution to iron and steel, and in this third paper he carries the research further. He finds that carbon is dissolved as such in pure iron by a sufficiently high temperature. The molecule of the dissolved carbon between 1600° and 1300° C. consists of two atoms. It increases with decreasing temperature, and at 1150° C. nearly equal amounts of two and three atom molecules are present in the solution. At a still lower temperature, there is in the solution, besides a certain amount of free carbon increasing with the content of carbon present, iron carbide. At first the latter remains in solution with the free carbon (austenite). If, however, its quantity increases above a certain amount, the alloy separates into two parts. In the one the free carbon prevails, in the other the carbide of iron (martensite) prevails. With falling temperature, the amount of the iron carbide increases, as also does the martensite, whilst the quantity of the austenite decreases until at length only martensite is present.

Mr. Enrique Disdier contributed a paper on the use of blast-furnace and coke-oven gases, in which he urged that coke-oven gases should be heated by blast-furnace gases and the oven gases used for driving gas engines. By the adoption of this method of utilising the gases, the cost of pig-iron would, he asserts, be reduced by 5*s.* 5½*d.* per ton. In the discussion, Mr. James Riley expressed the opinion that the author had worked out his case well, but considerable difficulties would have to be surmounted before his theory was put into practice. Mr. Hugh Savage described the progress that had been made in Belgium in the use of blast-furnace gases as motive power. Mr. Charles Wood and Mr. Enoch James anticipated difficulty from the dust in the gases.

Mr. Bertrand S. Summers, of Chicago, contributed a lengthy paper on theories and facts relating to cast-iron and steel. In the discussion, Mr. R. A. Hadfield expressed the opinion that there was a demand among electricians for material of high permeability and of low cost, and he thought that the author had done much to render this possible. Mr. W. Mordy also discussed the paper from the electrician's point of view.

The last paper on the list was from the pen of the great Russian metallurgist, Mr. D. Tschernoff. It described a construction of blast-furnace in which gas is used in lieu of solid fuel, and in which iron or steel may be produced direct from the ore.

The usual votes of thanks were carried, and the meeting, which throughout was largely attended and most successful, was declared at an end. On the evening of May 4, the annual dinner was held at the Hotel Cecil, and on May 5 the members were entertained by Sir William and Lady Roberts-Austen at their residence in the Royal Mint.

## THE ROYAL SOCIETY'S CONVERSAZIONE.

THE first of the two soirées held annually at the Royal Society took place on Wednesday, May 3. There was a large collection of apparatus and many interesting exhibits, but our space only permits us to refer to some of those which attracted most general attention; these are as follows:—

Mr. Thomas Andrews, F.R.S., exhibited microscopic structure of heavy steel guns, projectiles, and warship propellor shafts.

The Tsetze Fly Committee of the Royal Society showed enlarged photographs, taken by Surgeon-Major Bruce, illustrating districts in South Africa affected by the Tsetze Fly Disease.

Mr. A. Mallock exhibited thin films used as mirrors. The films are formed by allowing a solution of pyroxyline in amyl acetate to spread on the surface of water. The films being removed when the solvent has evaporated, are then stretched over rings, whose edges have been ground to a true plane, and silvered.

Dr. Patrick Manson and Surgeon-Major Ross exhibited the development of *Filaria nocturna*, Manson, and of *Proteosoma grassii*, Labbé (one of the parasites of malaria of birds), in the mosquito.

Prof. W. N. Hartley, F.R.S., and Prof. J. J. Dobbie exhibited photographs of absorption spectra of organic compounds, showing the method of investigating peculiar cases of isomerism called tautomerism or desmotropy.

Mr. Edwin Edser showed the phase-change associated with the reflection of light from a fuchsine film. Two unsilvered glass plates, forming the end mirrors of a Michelson interferometer, are provided with films of fuchsine on their back surfaces. A horizontal strip of fuchsine is removed from one of the mirrors. Interference fringes are produced by means of rays of light reflected from the fuchsine films; these fringes are focussed on the slit of a spectroscope. The resulting spectrum is found to be crossed by vertical dark bands. In the violet and blue, the bands formed by reflection, in the glass, from fuchsine and air respectively, are seen to be continuous. Since fuchsine is optically less dense than glass for blue light, this is in agreement with theory. Passing onward toward the red end of the spectrum, a gradual displacement occurs in the bands produced by the light reflected from the fuchsine. Red light is seen to be retarded by half a wave-length when reflected from fuchsine.

Mr. Shelford Bidwell, F.R.S., exhibited experiments demonstrating multiple vision; Mr. James Swinburne, Nernst electric lamps; Dr. Woodward, F.R.S., a selection of zoological specimens from Christmas Island (Indian Ocean), collected by Mr. C. W. Andrews; Dr. Francisco P. Moreno, Director of the La Plata Museum, Argentine Republic, portion of skin of an extinct ground-sloth, named *Neomylodon listai* by Ameghino, from a cavern in Southern Patagonia; and Dr. G. Herbert Fowler, examples of floating organisms from the surface and deep water of the Faeroe Channel.

Sir W. Crookes, F.R.S., exhibited new photographic researches on phosphorescent spectra. It has long been known that certain substances enclosed in a vacuous glass bulb phosphoresce brightly when submitted to molecular bombardment from the negative pole of an induction coil. The ruby, emerald, diamond, alumina, yttria, samaria, and a large class of earthy oxides and sulphides emit light under these circumstances. Examined in a spectroscope, the light from some of these bodies gives an almost continuous spectrum, while that from others, such as alumina, yttria and samaria, gives spectra of more or less sharp bands and lines. The exhibitor showed photographs of a group of lines high up in the ultra-violet region, characteristic of a new element associated with yttrium, and separated by long fractionation. To this element the name Victorium has been given. The atomic weight of Victorium is probably near 117. In the purest state in which it has yet been prepared, Victoria is of a pale brown colour.

The Marine Biological Association showed (1) methods of feeding of marine animals, illustrated by living and preserved examples; (2) charts illustrating the distribution of the fauna and bottom-deposits near the thirty-fathom line from the Eddystone Grounds to Start Point.

Mr. Adam Hilger showed the Michelson echelon grating spectroscope.

Prof. Arthur Thomson exhibited a model to illustrate how natural curliness of the hair is produced. Three factors require consideration in the production of curly hair: (1) the hair shaft, (2) the hair muscle, and (3) the sebaceous gland. Straight hair is always circular on section, and is usually thicker than curly hair, which is ribbon-like and fine. In order that the muscle may act as an erector in the hair, it is requisite that the shaft of the hair embedded of the skin should be sufficiently strong to resist any tendency to bend; unless this be so the lever-like action necessary to produce its erection is destroyed. When the hair is fine and ribbon-like, the shaft is not sufficiently stout to resist the strain of the muscle and naturally assumes a curve, the degree of curvature depending on the development of the muscle, the resistance of the hair, and the size of the sebaceous gland. The curve thus produced becomes permanent and affects the follicle in which the hair is developed, the softer cells at the root of the hair accommodate themselves to this curve, and becoming more horny as they advance towards the surface, retain the form of the follicle, the cells on the concave side of the hair being more compressed than those on the convex side. In this way, the hair retains the form of the follicle after it has escaped from it.

Dr. Sorby, F.R.S., showed (1) Actiniæ and other marine animals killed by menthol and preserved in formalin in a fully expanded condition, and the same mounted as transparent lantern slides. The addition of a little menthol to sea water in which the animals are living causes them to expand very fully, and in many cases to die so. When completely dead they can be transferred to 4 per cent. formalin, and kept thus distended or mounted in balsam as lantern slides. (2) Various marine animals preserved as museum specimens in strong glycerine.

Prof. E. A. Schäfer, F.R.S., exhibited (1) specimens showing that after hemisection of the spinal cord Clarke's column undergoes atrophy on the same side below the lesion; (2) specimens showing that the fibres of the pyramidal tract terminate at the base of the posterior horn and in Clarke's column, and not in the anterior horn; (3) specimens showing that the fibres of the descending antero-lateral tract terminate in the anterior horn.

Prof. H. L. Callendar, F.R.S., exhibited recording pyrometers—platinum and thermo-electric.

Mr. W. Duddell showed an oscillograph for tracing alternate-current wave-forms. This oscillograph is arranged for tracing the wave-forms of potential difference and current in investigations with alternating currents. It is essentially a galvanometer which has the extremely short periodic time of one ten-thousandth (0·0001) second, and which is perfectly dead-beat, and has a sensibility, as arranged, of 300 mm. per ampere.

Prof. Hele Shaw and Mr. A. Hay showed how lines of force in a magnetic field could be determined by the stream lines of a thin film of viscous fluid, and also plotted from mathematical investigation.

Prof. W. F. Barrett showed a new thermo-electric combination, giving a nearly constant electromotive force through a wide range of changing temperature.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—A meeting of the Junior Scientific Club was held on May 6. Mr. E. H. J. Schuster (New College) exhibited some excellent lantern slides of shore life.—This being the 200th meeting, Mr. G. C. Bourne (New College) read a very interesting paper on the early constitution of the Club, after which the Club adjourned. The officers for the ensuing term are—President, E. Gurney (New College). Secretaries, A. G. Gibson (Christ Church), H. E. Stapleton (St. John's). Treasurer, F. W. A. Fleischmann (Magdalen). Editor, F. W. Charlton (Merton).—Owing to medical advice, Prof. E. Ray Lankester, F.R.S., finds that he will be unable to deliver the Boyle Lecture of this year. Prof. J. G. McKendrick, F.R.S., has consented to take his place, and will lecture on "Musical sensations and the inner ear" on June 13.

CAMBRIDGE.—Prof. Sims Woodhead will deliver an inaugural lecture on the relations of pathology to modern medicine, in the Anatomy Theatre on May 23, at 2.30 p.m.

Mr. P. T. Main (sixth wrangler, 1862), who was for many years Lecturer in Chemistry and Superintendent of the Laboratory of St. John's College, died in his rooms on May 5.

The examinations in Agricultural Science for the University's diploma will extend from June 12 to June 19.

On November 7 two groups of colleges will hold examinations for entrance scholarships and exhibitions in Natural Science. One group includes Pembroke, Caius, King's, Jesus, Christ's, St. John's, and Emmanuel; the other Trinity, Clare, and Trinity Hall. The scholarships are of the value of 80*l.* a year and under. At the first group the subjects of examination are: (1) chemistry, (2) physics (including dynamics and hydrostatics), (3) physical geography (as introductory to geology), (4) animal physiology, (5) biology (including zoology and botany). In all branches of Natural Science there will be an examination in practical work. No candidate will be examined in more than *three* of the subjects numbered (1) to (5). Candidates who wish to offer elementary biology as a subject will be examined by means of the more elementary questions contained in the papers on biology. Opportunity will be afforded to candidates in biology to give evidence of their knowledge of natural history, and opportunity will also be given to candidates in physics to show proficiency in mathematics by means of a paper of a somewhat more advanced character than the *test paper* in mathematics. Those who wish to be examined in physical geography or physiology must give notice to that effect not later than October 23.

Information as to the range of the examination in physical geography may be obtained on application to any of the colleges.

At the second, the subjects are physics and chemistry. Papers will also be set in zoology, botany, physiology, geology, or other tripos subjects, provided that notice be given to the tutor not later than October 10. The notice should be accompanied by a list of the text-books which have been read by the candidate. Candidates for an emolument at Clare College may also offer elementary biology.

Further information may be obtained from any of the college tutors.

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THE International Congress on Commercial Education was opened at Venice on Thursday last in the Senate Hall of the Doges' Palace. Signor Pascolato, the president, delivered the opening address, in which he bade the foreign representatives cordially welcome. Dr. L. Saignat, representing France, gave a review of the work accomplished in the five previous congresses on commercial education, and thanked the Government and the King and Queen of Italy for the reception accorded to them. Other speeches followed. At the afternoon sitting, the Congress discussed the subject of a commercial school, its purpose, its limits, and its organisation. Other cognate subjects were considered at subsequent meetings. The next Congress will be held in Paris in August 1900.

THE Committee of Council on Education in Scotland has resolved that a sum not exceeding 2000*l.* shall be added to the amount payable under the "Education and Local Taxation Account (Scotland) Act, 1892," towards defraying the cost of the inspection of higher class schools in Scotland, and of the holding of examinations for and granting the leaving certificates of the Scotch Education Department. They have also resolved that a sum not exceeding 2000*l.* shall be set aside for the further encouragement of agricultural education in Scotland, to be distributed on conditions which shall hereafter be set forth by the Scotch Education Department. The remainder of the balance available under the section is to be applied in aid of such higher class secondary or technical schools in Scotland as are not in receipt of grants under the Scotch Code.

IN the House of Commons on Monday, Mr. Gerald Balfour introduced a Bill to establish a Department of Agriculture and other Industries and Technical Instruction in Ireland. Describing the principal provisions of the Bill, the right hon. gentleman stated that, as far as concerned the transfer to the new department of existing Governmental functions, the measure closely resembles its predecessor, but that to the powers and duties formerly proposed to be transferred are now added those of the fishery inspectors and most of the functions exercised by the Science and Art Department. With regard to the machinery and funds for carrying out the work of developing agriculture and other industries, considerable changes have been introduced, and the provisions with respect to technical instruction are new. For the purposes of the Bill there will be placed at the disposal of the department, in addition to certain moneys annually voted by Parliament, a total income of between 160,000*l.* and 170,000*l.* a year. It is proposed that the chief sources of this income shall be the Imperial Exchequer, the Irish Church Fund, and the savings effected under the Judicature Act of 1897. 55,000*l.* is to be allocated to technical instruction of an urban character, and 10,000*l.* will go to purposes connected with sea fisheries. The rest of the money is to be used in connection with rural industries. The department is to be assisted by an agricultural board and a board of technical instruction, and only a minority of the members of these boards will be nominated by the Government. It is to be a general rule that no money is to be spent by the department in any local object without some contribution from local sources. The Bill was read a first time.

IN an address to students of the London Society for the Extension of University Teaching, delivered on Saturday afternoon in the Mansion House, Dr. Hill, Master of Downing College and Vice-Chancellor of the University of Cambridge, made the following remarks with reference to science teaching:—The too early teaching of science is not productive of permanent excellence in that department. The classical boys do far better, for they approach the new subject with an intelligence well drilled, with mental sinews well exercised and developed. The true way of approaching science at school is not to prepare boys for science scholarships, but to let scientific interests run like a thin line through school life—to induce a love of nature and beautiful objects. Experience in examining for the science tripos and the medical examinations is discouraging, and, astonishing as is the knowledge of facts displayed by candidates, their mental grip and conception of principle are unsatisfactory. But it is still to be remembered that a wrangler cannot be turned into a biologist, and mathematics dealing with abstractions are not well calculated to make a man a good observer of nature. The qualities needed for a man of science are many—quickness of observation, tenacity of memory, ratiocinative power—and no one course of study can be trusted to produce those results. The individual, however, is the main element, and there is needed in the several cases presented as great variety of mental as of physical nutriment for the body. In any case, however, wide sympathies are needed; the literary man would be the better for some knowledge of science, and the scientific man for a keen interest in literature. The University is charged sometimes with undue extension into technical subjects—to make men farmers, brewers, lawyers, and the like. It is not so, but the University desires to imbue the farmers and others who came to her with a love of knowledge, an elevated taste, a highly trained intelligence.

A GENERAL meeting of Convocation of the University of London was held on Tuesday, Mr. E. H. Busk, chairman of convocation, presiding. The *Times* reports that the Chairman, in replying to Prof. Silvanus Thompson, stated he could not say that, in the ordinary use of the word, negotiations were in progress for the transference of the business of the University to the Imperial Institute. If there were negotiations in progress they were only in a preliminary stage. The position of the matter was this. A communication was received from the Government requesting that a conference might take place between three representatives of the Treasury, three representatives of the University, and three representatives of the Imperial Institute—nine persons in all, who were to inspect the buildings and the grounds belonging to the Imperial Institute at South Kensington, and to consider whether those premises either were suitable or could be made suitable for the headquarters of the University in any way; and, if so, it was thought that the Government might enter into an arrangement with the authorities of the Imperial Institute which would enable them to make a proposal to the University. The nine representatives were duly appointed; they had inspected the building, but they had not yet reported.—Dr. H. F. Morley moved the reception of the report of the standing committee dealing with the regulations at the matriculation examination, aud recommending various resolutions for adoption by Convocation. The report was received. Dr. Morley then moved a resolution requesting the Senate to adopt for the matriculation examination a scheme of subjects which was in complete accordance with the scheme that was unanimously adopted by the meeting of delegates from the Board of Studies in the Faculty of Arts. After some discussion the scheme of subjects was adopted by the house in the following form:—(1) Latin (two papers); (2) English (two papers); (3) mathematics (two papers); (4) any two of the following five languages:—Greek, French, German, Sanskrit, Arabic; and (5) one of the following five sciences:—Elementary mechanics, elementary chemistry, elementary sound, heat, and light, elementary magnetism and electricity, and elementary botany.

## SCIENTIFIC SERIALS.

*Bulletin of the American Mathematical Society*, April.—Prof. F. N. Cole gives an abstract of the *Proceedings* of the February meeting of the Society. For nearly a year plans have been under discussion for providing facilities for the publication of the increasing number of original mathematical papers produced in America. The Committee appointed at the last summer meeting have reported that it is desirable and feasible that the Society should undertake the periodical publication of *Transactions*, and that a commencement should be made in January 1900.—Nineteen papers were presented at the meeting.—Abstracts are given of papers by Prof. Macfarlane (on the imaginary of geometry), by Prof. Osgood (on a means of generating a function of a real variable whose derivative exists for every value of the argument, but is not integrable), by Prof. Lovett (on a certain class of invariants), by Dr. Snyder (lines of curvature on annular surfaces having two spherical directrices), by Dr. Miller (on the primitive groups of degree 17), by Dr. Dickson (concerning the abelian and hypo-abelian groups), by Mr. Hedrick (on three-dimensional determinants), and by Dr. Ling (an examination of groups whose orders lie between 1093 and 2000).—Prof. Webster exhibited a large number of curves traced by the motion of a rotating top.—Prof. J. M. Peirce follows the above notice with an abstract of his paper on determinants of quaternions, read at the above meeting.—The largest linear homogeneous group with an invariant pfaffian, by Dr. L. E. Dickson, was read at the October meeting of the Society.—Asymptotic lines on ruled surfaces having two rectilinear directrices, by Dr. Snyder, was communicated (partially) at the August and December meetings. There are several diagrams. The theorem discussed is every ruled surface contained in a linear complex has an asymptotic line, all of whose tangents belong to the complex (*cf.* Clebsch, "Ueber die Curven der Hauptstangenten bei windschiefen Flächen," *Crelle*, vol. lxviii.; and Bonnet, "Théorie générale des Surfaces," *Journ. de l'École Polytechnique*, vol. xxxii.).—There are reviews of "Theoretical and Practical Graphics," by F. N. Willson, of "The repertorio di matematiche superiori, i. Analisi per E. Pascal," and of "D'Ocagne's Cours de Géométrie descriptive et de Géométrie infinitésimale." The last two notices are by Prof. Lovett, who also contributes a translation of Prof. G. Darboux's obituary sketch of Sophus Lie (*Comptes rendus*, February 27).—Interesting notes and publications close the number.

*Bollettino della Società Sismologica Italiana*, vol. iv., 1898, No. 8.—Obituary notice of P. Landi.—On the different methods of determining the position of the epicentre in distant earthquakes of unknown origin, by G. Agamennone and F. Bonetti. The authors argue that methods which depend on the length of the interval between the two series of undulations and on their direction cannot give trustworthy results. They prefer one based on the time-records of a particular phase of the movement, and they would make use of the slow-period pulsations rather than the earlier tremors, since the latter may traverse the body of the earth with a velocity depending on the density, while the former travel along the surface with a nearly constant velocity.—Two-component seismoscope, by C. Guzzanti.—Notices of the earthquakes recorded in Italy (November 27–December 31, 1897), by G. Agamennone, the most important being the Umbria and Marches earthquake of December 18–22.

## SOCIETIES AND ACADEMIES.

### LONDON.

**Royal Society**, April 20.—"Studies in the Morphology of Spore-producing Members. IV. Leptosporangiate Ferns." By F. O. Bower, Sc.D., F.R.S., Regius Professor of Botany in the University of Glasgow.

An attempt has been made in this memoir to strengthen the characters derived from the sorus by a fresh examination of its details, and certain of its features are used for purposes of general comparison which have hitherto received little attention; they are:—

(1) The relative time of appearance of sporangia of the same sorus.

(2) Certain details of structure of the sporangium, including its stalk.

(3) The orientation of the sporangia relatively to the whole sorus.

(4) The potential productiveness of the sporangium as estimated by its spore-mother cells, and the actual spore-output.

Observations of these features extending over all the more important living genera, coupled with data of habit and the characters of the Gametophyte as collateral evidence, have led the author to divide the homosporous ferns thus:—

| | | |
|---|---|---|
| Simplices | Marattiaceæ | Eusporangiate |
| | Osmundaceæ | Leptosporangiate |
| | Schizæaceæ | |
| | Gleicheniaceæ | |
| | Matonineæ | |
| Gradatæ | Loxsomaceæ | |
| | Hymenophyllaceæ | |
| | Cyatheaceæ | |
| | Dicksonieæ | |
| | Dennstaedtiinæ | |
| Mixtæ ... | The bulk of the Polypodiaceæ | |

The effect of the observations and comparisons in this memoir is rather confirmatory of the current classifications than disturbing. The divisions suggested would supersede those of Eusporangiatæ and Leptosporangiatæ, though these terms would still be retained in a descriptive sense. If the sub-orders Osmundaceæ, Schizæaceæ, and Marattiaceæ be transferred from the end of the Synopsis Filicum to the beginning, and grouped with *Gleichenia* and *Matonia*, we have the "Simplices" before us. They are characterised by the simultaneous origin of the sporangia. The Gradatæ, in which the sporangia are produced in basipetal succession, include the Cyatheaceæ, Dicksonieæ (*Excl. Dennstaedtia*), Hymenophyllaceæ, and Loxsomaceæ, sequences probably of distinct descent, and probably derivative from some prior forms such as the Simplices; and in the arrangement of Sir Wm. Hooker they hold a position following on the Gleicheniaceæ. The family of Dennstaedtiinæ, founded by Prantl to include *Dennstaedtia* and *Microlepia*, also has its place here, but it leads on by intermediate steps to undoubtedly mixed forms in which various ages of sporangia appear without regular sequence, such as *Davallia*, *Cystopteris*, *Lindsaya*, and the Pterideæ. But this sequence is already laid out in this order in the Synopsis, and it illustrates one at least of the lines along which mixed forms are believed to have been derived from the Gradatæ. No attempt has been made to follow the natural grouping of the Mixtæ into detail, or to test the arrangement of them in the Synopsis. Sufficient has, however, been said to show that the systematic divisions of the ferns now proposed fall in readily with the system of Sir William Hooker, notwithstanding that they are based upon details of which he cannot have been aware.

"The Physiological Action of Choline and Neurine." By F. W. Mott, M.D., F.R.S., and W. D. Halliburton, M.D., F.R.S.

The cerebro-spinal fluid removed from cases of brain atrophy after death or during life, particularly from cases of general paralysis of the insane, produces when injected into the circulation of anæsthetised animals a fall of arterial pressure, with little or no effect on respiration. This pathological fluid is richer in proteid matter than the normal fluid, and among the proteids, nucleo-proteid is present. The fall of blood pressure is due to an organic substance, which by chemical methods was identified as choline.

The nucleo-proteid and choline originate from the disintegration of the brain tissue, and their presence indicates that some of the symptoms of general paralysis may be due to auto-intoxication; these substances pass into the blood, for the cerebro-spinal fluid functions as the lymph of the central nervous system. We have identified choline in the blood removed by venesection from these patients during the convulsive seizures which form a prominent symptom in the disease.

Normal cerebro-spinal fluid does not contain nucleo-proteid or choline, and produces no effect on arterial pressure.

Our proof that the material we have worked with is choline rests not only on chemical tests, but also on the evidence afforded by physiological experiments; the action of the cerebro-spinal substance exactly resembles that of choline. Neurine, an alkaloid closely related to choline, is not present in the fluid;

its toxic action is much more powerful, and its effects differ from those of choline.

The fall of blood pressure is in some measure due to its action on the heart, but is also produced by dilatation of the peripheral vessels, especially in the intestinal area. The drug causes a marked contraction of the spleen, followed by an exaggeration of the normal curves, due to the alternate systole and diastole of that organ.

The action on the splanchnic vessels is due to the direct action of the base on the neuro-muscular mechanism of the blood vessels themselves.

The fall of blood pressure is abolished by atropine. This observation has some bearing on general paralysis, for the arterial tension in that disease is usually high, not low, as it would be if choline were the only toxic agent at work.

*Neurine* produces a fall of arterial pressure, followed by a marked rise, and a subsequent fall to the normal level. Sometimes, especially with small doses, the preliminary fall may be absent. Sometimes, especially with large doses, by which presumably the heart is more profoundly affected, the rise is absent.

The slowing and weakening of the heart account for the preliminary fall of blood pressure.

The rise of blood pressure which occurs afterwards is due to the constriction of the peripheral vessels, evidence of which we have obtained by the use of oncometers for intestine, spleen, and kidney.

After the influence of the central nervous system has been removed by section of the spinal cord, or of the splanchnic nerves, neurine still produces its typical effects.

After, however, the action of peripheral ganglia has been cut off by the use of nicotine, neurine produces only a fall of blood pressure. It therefore appears that the constriction of the vessels is due to the action of the drug on the ganglia.

It produces a marked effect on the respiration. This is first greatly increased, but with each successive dose the effect is less, and ultimately the respiration becomes weaker, and ceases altogether. The animal can still be kept alive by artificial respiration.

The exacerbation of respiratory movements will not account for the rise of arterial pressure; the two events are usually not synchronous, and an intense rise of arterial pressure may occur when there is little or no increase of respiratory activity or during artificial respiration.

After atropine, injection of neurine causes only a rise of blood pressure, which is accompanied with constriction of peripheral vessels.

**Chemical Society**, April 20.—Prof. Thorpe, President, in the chair.—The following papers were read:—The synthesis of some $\beta\beta'$-dipyridyl derivatives from citrazinic acid, by W. J. Sell and H. Jackson. Citrazinic acid yields a nitroso-derivative

$$\mathrm{COOH.C}\!\!\begin{array}{l}\diagup\,\mathrm{CH_2}\text{———}\mathrm{CO}\,\diagdown\\ \diagdown\,\mathrm{C(NO).C(OH)}\,\diagup\end{array}\!\!\mathrm{N},$$

from which a number of dipyridyl derivatives have been obtained.—Action of hydrogen peroxide on carbohydrates in the presence of iron, by R. S. Morrell and J. M. Crofts. Both glucose and lævulose are oxidised by hydrogen peroxide in presence of iron salts with formation of glucoson; under similar conditions, arabinose yields arabinoson.—The condensation of oxalic acid and resorcinol, by J. T. Hewitt and A. E. Pitt. The condensation product of oxalic acid with resorcinol in presence of sulphuric acid contains a compound of the composition $C_{20}H_{14}O_7$, which is probably a carboxylic acid.—Ethyl ammonium sulphite, by E. Divers and M. Ogawa. Ethyl ammonium sulphite is formed by the interaction of ammonia and sulphur dioxide dissolved in alcohol; it is immediately converted into alcohol and ammonium pyrosulphite by water.—Ethyl ammonium selenite and non-existence of amidoselenites (selenosamates), by E. Divers and S. Hada.—The allotropic modifications of phosphorus, by D. L. Chapman. Metallic and red phosphorus are identical, and the vapours of red and yellow phosphorus are also identical; red phosphorus melts, forming ordinary phosphorus, under pressure at the melting point of potassium iodide.—On the interaction of mercurous and mercuric nitrites with the nitrites of silver and sodium, by P. C. Rây.—$\beta$-Isopropylglutaric acid, by F. H. Howles and J. F. Thorpe. A new method of preparing $\beta$-isopropylglutaric acid from ethylic $\alpha$-bromisobutylacetate is given.—The synthesis and preparation of terebic and terpenylic acids, by W. T. Lawrence. $\beta$-Isopropylglutaric acid is oxidised by chromic acid mixture with formation of terpenylic acid; the constitution of the latter is therefore

$$\begin{array}{l}\qquad\qquad\quad\mathrm{CMe_2.O}\text{——}\!\!\urcorner\\ \qquad\qquad\quad\;\;|\qquad\quad\;\;|\\ \mathrm{COOH.CH_2.CH.CH_2.CO.}\end{array}$$

—Position-isomerism and optical activity; the comparative rotatory powers of methylic and ethylic ditoluylglycerates, by P. Frankland and H. Aston.—Fencholenic acid, by G. B. Cockburn. Fenchonoxime, when heated with dilute sulphuric acid, yields a mixture of two nitrites, which in turn give isomeric acids on hydrolysis.—The action of certain acidic oxides upon salts of hydroxy-acids, Part iv., by G. G. Henderson, T. W. Orr, and R. J. G. Whitehead.

**Royal Microscopical Society**, April 19.—Mr. E. M. Nelson, President, in the chair.—The President called special attention to two old microscopes; the first, which had been presented to the Society by Mr. J. M. Offord, was signed "Adams," and was a very interesting model which filled up a gap in the historic collection of the Society. Its probable date was about 1785-95. The second microscope, which had been presented by Dr. Dallinger, was one full of interest, and evidently constructed about the end of the last century; it was the earliest example in the Society's collection of a microscope with rack-work limb.—Dr. Hebb exhibited, on behalf of Miss Latham, two slides of blood which had been stained with methylen blue; one was of normal blood which had retained the blue stain, the other was of blood from a diabetic person; but in this the blue had been discharged, probably by the action of the glucose which is present in the blood in this disease.—Owing to illness Prof. Lionel Beale was unable to be present to read his paper.—Dr. Hebb read a letter from Mr. Bryce Scott, who said if any Fellows cared for West India dredgings rich in Foraminifera, he would be pleased to forward them some.—The President then, on behalf of the Society, presented to Mr. T. H. Powell an enlarged framed copy of the portrait of his father, the late Mr. Hugh Powell, which is issued as a frontispiece in the current number of the *Journal*.—The President then made a few remarks upon the theory and construction of eye-pieces for the microscope.—At the next meeting it is hoped Dr. H. C. Sorby will read a paper on the preparation of microscopical specimens of marine worms, and that there will be an exhibition of pond-life.

PARIS.

**Academy of Sciences**, May 1.—M. van Tieghem in the chair.—On continued groups, by M. H. Poincaré.—Iodine in sea water, by M. Armand Gautier. Iodine does not appear to exist in sea water in the form of iodides, since five litres gave a negative result. It would appear to be present in minute organisms, and amounts up to 2·4 mgr. per litre were found from this source. One-fourth of the total amount of iodine present can be separated by filtering through porcelain.—On traumatism and tuberculosis, by MM. Lannelongue and Achard.—Separation into two natural groups of the volcanic outflow of Mt. Dore; the distinctive chemical characters of their magmas, and of that supplying the eruptions of the "puys" of Auvergne, by M. Michel Lévy.—On a generalisation of Fermat's theorem, by M. L. E. Dickson.—On a transcendental equation and linear differential equations of the second order with periodic coefficients, by M. A. Liapounoff.—Note on the development of an arbitrary function and on a series proceeding according to harmonic functions, by M S. Zaremba.—Radioconductors with metallic spheres, by M. Edouard Branly. Columns of from six to fifteen balls of various metals were placed in series with a battery and electric bell. On exposing this column to the electric waves arising from a small induction coil, brusque variations of resistance are set up, causing the bell to ring. Thus with steel the resistance under these conditions fell from 2060 ohms to 120 ohms, with aluminium from 20,660 to 280 ohms, the resistance being in both cases restored by giving a slight shock to the column.—The production of chains of electrolytic deposits, and the probable formation of invisible conducting chains in distilled water under the action of induced currents and electric waves, and on a curious oscillation phenomenon produced in distilled water by induced currents of low frequency, by M. Thomas Tommasina.—On the magnetic rotatory polarisation of quartz, by M. Arnold-Borel.—Chemical analysis of some volcanic rocks arising

from the peripheral cracking of Mt. Dore, by M. E. Bonjean. Eleven analyses are given of phonolites, trachytes, tephrites, and basalts.—On a crystallised double carbonate of cerium peroxide, by M. André Job. The salt has the composition $Ce_2O_3.(CO_3)_3.4K_2CO_3.12H_2O$, and arises from the action of hydrogen peroxide upon cerium salts, and also by spontaneous oxidation.—On a fluorine compound supposed to be contained in certain mineral waters, by M. F. Parmentier. The effects produced upon glass, hitherto supposed to have been produced by fluorides in certain mineral waters, are shown to be due to a deposit of silica. No trace of fluorine has been detected in numerous analyses of mineral waters.—On the oxidising power of the alkaline periodates, by M. E. Péchard. The salt $NaIO_4$ behaves as an oxidising agent towards ferrous salts and potassium iodide.—Displacement of mercury by hydrogen, by M. Albert Colson. Mercuric oxide is slowly reduced by hydrogen at 100°, the amount of mercury formed being proportional to the weight of oxide actually present. The yellow and red oxides are reduced at different rates, the red being the slower of the two. Mercurous oxide is not attacked by hydrogen at 100.—Luminous phenomena produced by the action of certain ammoniacal salts upon fused potassium nitrite, by M. D. Tommasi.—Morphine and its salts, by M. Émile Leroy. A study of the heats of combustion and formation of various salts of morphine.—On the production of the racemoid forms of camphor, by M. A. Debierne.—On the unsymmetrical tetramethyl derivative of diamido-diphenylethane, by M. A. Trillat.—On the sugar from maize stems, by MM. C. Istrati and G. Oettinger.—On the absorption of iodine by the skin and its localisation in certain organs, by M. F. Gollard.—Detection and colorimetric estimation of minute quantities of iodine in organic substances, by M. Paul Bourcet.—The electrical treatment of gout, by M. Th. Guilloz.—On the structure of the anal glands in *Dysticus* and the supposed defensive *rôle* of these glands, by M. Fr. Dierckx.—Sporozoa in the digestive tube of the blind-worm, by M. Louis Léger.—On the quantitative variations of the plankton in the Lake of Geneva, by M. Emile Yung.—Fall of a meteorite recently observed in Finland, by M. Stanislas Meunier.—On a new mercury pump, by M. E. U. Chatelain.

## DIARY OF SOCIETIES.

*THURSDAY*, May 11.

Mathematical Society, at 8.—The Zeroes of a Spherical Harmonic $P_n^m(\mu)$ considered as a Function of $n$: H. M. Macdonald.—On the Statistical Rejection of Extreme Variations, Single or Correlated (Normal Variation and Normal Correlation): W. F. Sheppard.

*FRIDAY*, May 12.

Royal Institution, at 9.—Magnetic Perturbations of the Spectral Lines: Prof. Thomas Preston, F.R.S.

Royal Astronomical Society, at 8.—Observations of Swift's Comet 1899, made at Grahamstown, South Africa: L. A. Eddie.—Observations of Mars made at Mr. Crossley's Observatory, Bermerside, Halifax, during the Opposition 1898–99: Joseph Gledhill.—Note on the Spectra of γ Cassiopeiæ and o Ceti: Rev. W. Sidgreaves.—Longitude from Moon Culminations: D. A. Pio.——*Probable Papers*: Note on an Elbow Form of Reflecting Telescope: Dr. A. A. Common, F.R.S.—Observations of the Satellite of Neptune from Photographs taken with the 26-inch Refractor of the Thompson Equatorial: Royal Observatory, Greenwich.

Physical Society, at 5.—Note on the Vapour Pressure of Solutions of Volatile Substances. Dr. R. A. Lehfeldt.—Note on the Discussion of their Paper on the Criterion for an Oscillatory Discharge of a Condenser: Prof. W. B. Morton and Dr Barton.—Exhibition of a Quadrant Electrometer: G. L. Addenbrooke.

Malacological Society, at 8.—On *Planispira* (*Cristigibba*) *Buruensis* and *Omphalotropis hercules*, New Species from Buru: J. H. Ponsonby and E. R. Sykes.—Note on the Nervous System of *Ampullaria urceus*: R. H. Burne.—Notes on some Marine Shells from North-West Australia, with Description of New Species: E. A. Smith.—Descriptions of *Sigaretus Drewi*, n.sp. (Fossil) and *Cirsonella neozelanica*, n.sp. from New Zealand: R. Murdoch.—Notes on some New Zealand Land Mollusca: R. Murdoch.

*SATURDAY*, May 13.

Geologists' Association (Liverpool Street, G.E.R.), at 2.—Excursion to Ilford.

*MONDAY*, May 15.

Victoria Institute, at 4.30.—The Physical and Mental Attributes of the Sexes: Dr. A. T. Schofield.

*TUESDAY*, May 16.

Royal Institution, at 3.—Recent Advances in Geology: Prof. W. J. Sollas, F.R.S.

Zoological Society, at 8.30.

Royal Statistical Society, at 5.—Life Tables: their Construction and Practical Uses: T. E. Hayward.

Royal Photographic Society, at 8.—Specimens of Work with Irregular Grained Screens, &c.

*WEDNESDAY*, May 17.

Royal Meteorological Society, at 4.30.—The Mean Temperature of the Surface Waters of the Sea round the British Isles, and its Relation to that of the Air: H. N. Dickson.—Some Phenomena connected with the Vertical Circulation of the Atmosphere: Major-General H. Schaw, C.B.

Royal Microscopical Society, at 7.30.—Exhibition of Pond Life.

*THURSDAY*, May 18.

Royal Society, at 4.30.—Bakerian Lecture: The Crystalline Structure of Metals: Prof. Ewing, F.R.S., and W. Rosenhain.——*Probable Papers*: The Yellow Coloring Matters accompanying Chlorophyll and their Spectroscopic Relations: C. A. Schunck, F.R.S.—The Diffusion of Ions into Gases: J. S. Townsend.—The Diurnal Range of Rain at the Seven Observatories in connection with the Meteorological Office, 1871–1890: Dr. R. H. Scott, F.R.S.

Institution of Electrical Engineers, at 8.—Electric Locomotives in Practice and Tractive Resistance in Tunnels, with Notes on Electric Locomotive Design: P. V. McMahon.

Chemical Society, at 8.—Corydaline, Part VI.: Dr. J. J. Dobbie and A. Lauder.—Oxidation of Furfural by Hydrogen Peroxide: C. F. Cross, E. J. Bevan, and T. Freiberg.

*FRIDAY*, May 19.

Royal Institution, at 9.—Runic and Ogam Characters and Inscriptions in the British Isles: The Lord Bishop of Bristol.

## BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Books.—Zur Anthropologie der Badener: O. Ammon (Jena, Fischer).—A Class-Book of (Elementary) Practical Physiology: Dr. de B. Birch (Churchill).—Geometrical Drawing: E. C. Plant, Vol. 1, Practical Plane Geometry (Macmillan).—Medical Missions in their Relation to Oxford: Sir H. W. Acland, 2nd edition (Frowde).—The Hygiene of the Mouth: R. D. Pedley (Segg).—Die Physikalischen Erscheinungen und Kräfte ihre Erkenntnis und Verwertung im Praktischen Leben: Prof. L. Grunmach (Leipzig, Spamer).—Outlines of Physical Chemistry: Prof. A. Reychler, translated by Dr. J. McCrae (Whittaker).—L'Éclairage a Incandescence par le Gaz et les Liquides Gazéifiés: P. Truchot (Paris, Carré).—Transactions of the American Pediatric Society, Vol. x. (New York).—Elements of Quaternions: Sir W. R. Hamilton, 2nd edition, Vol. 1 (Longmans).—Mechanics applied to Engineering: Prof. J. Goodman (Longmans).—Text-Book of Practical Solid Geometry: Captain E. H. de V. Atkinson (Spon).—Steinbruchindustrie und Steinbruchgeologie: Dr. O. Hermann (Berlin, Borntraeger).—The Naval Pioneers of Australia: L. Becke and W. Jeffery (Murray).—Applied Geology: J. V. Elsden, Part 2 ("Quarry" Publishing Company).—A Guide to Recent Large Scale Maps (London).

Pamphlets.—Mines and Quarries, General Report, &c., for 1898, Part 1 (London).—The Geology of the Country around Carlisle: T. V. Holmes (London).

Serials.—Travaux de la Société Impériale des Naturalistes de St. Pétersbourg, Vol. xxvii. livr. 5 (St. Pétersbourg).—Sunday Magazine, May (Isbister).—Good Words, May (Isbister).—Chambers's Journal, May (Chambers).—National Review, May (Arnold).—Contemporary Review, May (Isbister).—Pearson's Magazine, May (Pearson).—Century Magazine, May (Macmillan).—Proceedings of the American Philosophical Society, December (Philadelphia).—Humanitarian, May (Duckworth).

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THURSDAY, MAY 18, 1899.

## TRAVELS IN NEW GUINEA.

*Through New Guinea and the Cannibal Countries.* By H. Cayley Webster. Pp. xvii + 387. (London: T. Fisher Unwin, 1898.)

AFTER perusal of this book we are not able to say that its title is strictly descriptive of its contents. It s as regards New Guinea too comprehensive, and too vague in respect of "the Cannibal Countries." It deals with adventurous cruises on the New Guinea coast, and among the islands from the Admiralty Group to the Solomons, with a land journey undertaken in German New Guinea. Of this our author says:

"In the interior of German New Guinea I traversed a greater distance on foot than any white man has done before or since, and on that expedition I discovered the non-existence of a range of mountains previously marked on the chart."

The printing of the book is as excellent as is the paper. The illustrations, some three hundred and fifty in number, are generally good, sometimes excellent. It contains one map, the weakest part of the work. It takes no heed of latitude or longitude, makes Captain Webster more than half cross New Guinea, and sail recklessly over great islands. It is in every respect inferior to older maps. The style of the book is light and easy; the spelling of German names inaccurate. Captain Webster is in some ways typical of the travelling Englishman, ready to go anywhere, but by preference where there is danger to be incurred, and with a mission to put right whatever he finds wrong. We meet him engaged in this way at Batavia, where we take up his narrative. On the German steamer were many coolie labourers. The Government agent kicked, bullied, and ill-used them till Captain Webster, who was only a passenger, interfered. But our author is also an enthusiastic collector. He writes:

"One of my earliest captures [in German New Guinea] was a magnificent specimen of the *Ornithoptera paradisea*, of which only one specimen had before reached Europe, and I felt that it was worth the whole of my journey to New Guinea to see this superb insect lying glistening in my hand."

On November 9, 1893, he reached the headquarters of the New Guinea Company, and received every kindness and assistance from the Governor. A day or two afterwards he saw a coolie flogged for having induced some others to run away. He thought the terrible punishment inflicted exceeded the offence. He found the natives true Papuans, but wisely abstains from describing a Papuan. Captain Webster noticed a strong Hebrew type running through their features, "as indeed I have seen throughout the whole of the country, both in British, German, and Dutch possessions." Surely he did not find this common from Hale Sound to Kiriwina.

He observes that they all smoke tobacco—apparently speaking of the natives of German New Guinea—"which has been introduced into the country by Europeans." He states that he has "on more than one occasion observed a mere infant remove the pipe from his mouth to refresh himself from the natural food provided by his mother." This we presume is to be regarded as a figure of speech.

The introduction and distribution of the tobacco-plant is, however, of real scientific interest. Romilly ("The Western Pacific and New Guinea," p. 226) says of Astrolabe Bay, "Tobacco I should say there certainly was not." He would thus appear to agree with Captain Webster, who carried out his explorations in that district. But Giglioli (p. 120, "I Viaggo del Pattore," O. Beccari) quotes a letter from a Russian officer of the *Vitiaz*, from which Maclay landed in Astrolabe Bay in 1871, which says: "In quanto al tabacco essi [the natives] lo coltivano, e, lo fumano, rivoltandolo in una foglia di banana." On the other hand, we know from the British New Guinea Reports that seven or eight years ago it had not reached the low lands of the large rivers on the north-east coast of that colony.

Our author also relates that he has seen a Papuan woman "nourishing her child and a small pig at the same time, carrying one under each arm, appearing to be more anxious for the welfare of the latter, in consequence of its greater market value." We are aware that if a Papuan woman loses her child she sometimes employs a small pig to remove, and, it may be, to utilise the lacteal secretion. We have, however, never seen a Papuan woman carry her child under her arm, though they do carry dogs and pigs in that way. Captain Webster does not say where he saw this; but at p. 29 we are told what he gave for a small boy. It was more than the market value of a young pig.

Captain Webster's only journey towards the interior was on the watershed of Astrolabe Bay. Romilly wrote:

"Astrolabe Bay has always been looked upon, for some reason unknown to me, as a suitable place for a party of adventurers to swoop down upon and take possession of."

The reason why travellers prefer it is that it offers apparent easy access to the interior. When our author wrote his book, he was evidently unacquainted with the German literature that deals with the Astrolabe Bay district.

The officers of the Russian corvette *Vitiaz* mapped it in 1871, and Guido Cora published the map in 1875. Maclay was in 1871 or 1872 as far inland as the top of the coast range (*Nachrichten über Kaiser Wilhelms Land*, 1896), Zöller and Lauterbach will be mentioned later. The Governor furnished Captain Webster with military police and carriers, under the command of Pierson, who perished later with Herr Otto Ehlers in an unfortunate attempt to cross New Guinea from north to south. It has been claimed for Captain Webster by his publisher that he discovered the Minjim River; he asserts himself that he followed its stream to its source, and he has a photograph of it which purports to say "Hier ist des Stromes Mutterhaus," though it does not look like it. Zöller ("Ersteigung des Finisterre-Gebirges," 1891) found that the road from two German plantations crossed the Minjim. It was, therefore, when Captain Webster arrived in the bay, well known to every one there except himself. Zöller forded the Minjim near the sea, and found it knee-deep in the dry season. In German writings it is sometimes termed a *Bach*, sometimes a *Fluss*. It was in flood when Captain Webster's

party started, but they forded it eleven times in that condition the first day, having, however, many narrow escapes. They left Stephansort on March 22, and reached their furthest distance on April 10. In giving no map of this journey Captain Webster is just neither to himself nor to his reader. Where he really got to, it is quite impossible to say. But this much is clear: that as the Minjim valley runs from the coast towards the Ramu nearly at right angles, and as our author did not reach the Ramu, and never left the watershed of the Minjim, his claim to have beaten the German record falls to the ground, and need not be further considered.

The second and most important geographical discovery of Captain Webster is of a decidedly negative character. He unhesitatingly asserts the non-existence of the great Bismarck Range, of which the German travellers are not a little proud, as it is the highest part of their colony, and on their map a note, "Zeitweise Schnee," appears at a spot where Captain Webster's map makes him cross the range.

The Bismarck Range was discovered and named by Dr. Otto Finsch ("Samoafahrten," 117). He estimated its altitude with wonderful accuracy at 14,000 to 16,000 feet; its distance from the coast at seventy or eighty miles. It was seen by Romilly (*loc. cit.*, 227). Zöller says that in clear weather it is visible from Astrolabe Bay. In his "Routenskizze der Expedition in das Finisterre-Gebirge," Zöller gives the bearings from his highest point on that range to the different summits of the Bismarck Range. These, with bearings from Astrolabe Bay, must give the position with sufficient approximation to accuracy. In 1896, Drs. Lauterbach and Kersting examined the middle course of the Ramu, and actually ascended from thence some of the slopes of the Bismarck Range (*Nachrichten*, 1896, 42) to an altitude of 1000 metres. Lauterbach's positions were determined by astronomical observations, since published. Against this we have the statement of Captain Webster, that from his furthest point he "ascertained the true position of the Albert Victor Range of mountains in British New Guinea," which he thinks was mistaken by "some," who proudly named it after the late ex-Chancellor. In what manner our author ascertained in a few hours the true position of a mountain in British New Guinea from a single unknown and undetermined point on the Minjim will probably remain unknown for all time.

We entertain no doubt that Captain Webster, from his position on the watershed of Astrolabe Bay, was looking at the Bismarck Range itself in the distance. It should interest him greatly to peruse the reports on the splendidly conducted and completely successful expeditions of Zöller (1888) and Lauterbach (1896), and to study their maps, prepared and worked out on scientific principles. If our author will do that, he will wish to rewrite his preface.

In May 1894, Captain Webster visited New Britain just after a massacre of white men, and received the proverbial hospitality of Ralum. He gives an interesting account of how Mrs. Parkinson defeated a native attack, and relates how "the natives for many miles round worship the very ground she walks upon." This follows the very remarkable statement:—

"Within a mile or two of Ralum one may find, even to-day, chiefs who keep slaves for the purpose of food, and who are in the habit of killing them every few days to satisfy their diabolical tastes."

Now there lives at Ralum the enlightened and philosophic Parkinson, a name known to, and deservedly held in high esteem by many of the best men in Europe and elsewhere. That the atrocities mentioned by Captain Webster should be in constant practice under the eye, so to speak, of Mr. and Mrs. Parkinson, it is not easy to comprehend. The attitude of the German authorities is not alluded to by our author. He visited the Sacred Heart Mission, which he pronounced to be "excellent." His historical account of the mission is not quite accurate. The missionaries did not, according to this story, leave Woodlark Island on account of its small size, or of fever, but because they could do nothing with the natives. He states that the country has been divided into Protestant and Catholic countries. We know, from a recent issue of the *Illustrirte Zeitung*, that these divisions are not observed by the Roman Catholic missions in other German colonies. Captain Webster does not say whether the boundaries are respected in New Britain, but he states that the mission is obliged by law to teach the children to read and write German.

He then visited the Solomon Islands, where, as usual, several murders had been committed. He points out that ships of war cannot deal with these matters, a fact that has long been well known to those who study the subject. Captain Webster says the Solomon Islanders are all cannibals, and that the practice of offering up human sacrifices on even the most trivial occasions prevails throughout the group. No information whatever is vouchsafed as to the nature of this strange sacrificial practice.

On page 136, Captain Webster says:—

"I have been an eye-witness to more than one such expedition (head-hunting raids) when a large haul had been made, and more than sixty trophies in the shape of heads had been captured, which were immediately smoke-dried and preserved by being plastered over with chinam."

It is much to be hoped that in the interests of social and political evolution Captain Webster may in the proper place lift the veil on his unique and gruesome experiences. He does not state where or when he assisted at these scenes, which must be very rare. We are not able to believe that "heads" can be preserved in the manner described by our author. The few we have seen had been carefully preserved by a different process, on rational and scientific principles.

Captain Webster brought his visit to the Solomons to a characteristic close by backing out in the presence of a hostile tribe with his face to the foe and his revolver in his hand.

The second part of his book shifts the scene to the Batavian archipelago. On the south-coast of Dutch New Guinea the author met Arab traders, and Christian missionaries who are making very little progress. At the Kei Islands he met his yacht, and was henceforth master of his own movements. He sailed for the nearest part of the New Guinea coast, provided with hunters, and the yacht armed with a quick-firing Krupp gun.

The party next reached British New Guinea. Our author found Port Moresby dreary and dried up. It has often been described as picturesque. He tells us the dress of the men consists "only of a small piece of cord round the waist." The dress does consist of a piece of small cord; but a respectable member of the community would be as much scandalised to appear in public dressed as described by Captain Webster as would be that gentleman himself. The philosophy of clothes offers in New Guinea a great field for the student, but it is not so near the surface as Captain Webster thinks. On the way to Samarai they saw

"numerous villages along the coast, and cocoa-nut trees in great profusion were observed high up on the mountains, but I was informed (says Captain Webster) that the natives were very treacherous and have a bad reputation."

As a matter of fact they are, according to the British New Guinea Reports, under the control of the village police all along the coast from Port Moresby to Samarai, and are settled communities. At Samarai he found "a judge from Queensland presiding there to try the numerous small native cases." It did not occur to Captain Webster that the Queensland judge would have no jurisdiction in another colony. He visited native villages in that district. He describes the weapons of the natives as "bows, arrows and spears." The bow and arrow is, however, not used east of Port Moresby He visited Kwato, and pays a meed of praise to the mission there. He adds:

"At night could be heard far away in the forest weird sounds from their tom-toms and drums, wailings and shouting, which told us that their lewd dances and other disgusting orgies were taking place."

This is a *tour de force* of the imagination fit for the "Inferno" of the Divina Commedia. In sober fact there is no man within "tom-tom" range of Kwato that is not a church-goer. The great fault one really has to find with their dances is their dull, dreary monotony. The disgusting orgies are not scientific facts. John Knox said to his Queen:

"And of dancing, madam, I do not utterly damn it."

He was right. No wise Government will try to put down dancing, especially in a coloured population. Its suppression has been attempted more than once in the Pacific. In the code of M. Tardy Montravel it was enacted:

"13° Toute danse nocturne est interdite. Les delinquants seront punis d'un emprisonnement de un à trois jours."

Of this Paul Cordeil, chief of the Judicial Service of New Caledonia, writes:

"Les codes de M. de Montravel sont toujours restés lettre morte."

Let legislators and travellers take warning accordingly. Dancing is, next to eating, the greatest enjoyment the Papuan has. The drum is silent only after death or disaster. It is only unacquaintance with the drum and the dance that connects these with heinous sin. Assignations are doubtless made at dances. They would be made in any case. It was in church that Petrarch fell in love with Laura, and Boccaccio with Fiametta.

Nothing noteworthy occurred after the party left Kwato till they met with the "duk-duk" in the German Islands. Captain Webster thinks it was invented in the Duke of York group as a form of native police. His view of it is far too narrow. Many natives came off to them on the coast of New Ireland. "They are all ferocious cannibals and very treacherous. Many had been to Fiji, to Samoa, and Queensland, but they are none the more to be trusted." They landed at New Hanover, assisted at some festivities, saw some pretty dances, and obtained photographs. Of course these dances were seen by Captain Webster, and were decent. Here he "found that the natives have a belief that every man, woman, and child belong to one or other species of birds, according to the lines of the hands." He connects this with the old palmistry of our forefathers. We recognise it as belonging to the totemism that exists or existed from the St. Lawrence to the west end of New Guinea, and probably much further. But we shall before long hear more on this subject from Captain Webster's distinguished host at Ralum.

The party then proceeded to the Admiralty Group, but did not dare to land there.

The last chapter is a summary of anthropology and ethnology. It requires to be regarded cautiously before it can be used for scientific purposes.

The collections made were large. In birds it was disappointing, at least as regards those of the Paradise family. The insects turned out better. The specimens collected are already to be met with in museums from the south of Italy to the north of Germany. Captain Webster has therefore the satisfaction of knowing that, as a collector, he has made a contribution to the sum of human knowledge.

## OUR BOOK SHELF.

*The Philosophy of Memory, and other Essays.* By D. T. Smith, M.D. Pp. 203. (Louisville, Ky.: J. P. Morton and Co., 1899.)

DR. D. T. SMITH is an amateur of philosophy in that wider sense of the word which includes physics, and his speculations, as they are modestly put forward in the present volume, range from psychology to sphere-formation, and from the distinction of organic and inorganic to an adverse criticism of the nebular hypothesis. The essay which gives its title to the book is an attempt, notwithstanding the sterility of the inorganic and the reproductive capacity of the organic, to trace continuity, and apply analogies, from the one to the other, in the form of a physical-vibration theory of ideation. Even conscience is an "orderly operation of ether vibrations with respect to conduct." The second essay, on emphasis or rhythm, is a further application of the wave-theory. The third paper, on "the functions of the fluid wedge," is interesting as suggested by the author's expert physiological studies, and carried out in the alien field of hydrostatics. The present writer confesses to non-comprehension. The fourth essay objects to the nebular hypothesis that the facts of rotation are against it. "The earth could revolve on its own separate axis in the same direction as the sun only by

being caused to move in a larger orbit than that described by it while still a part of the sun's mass," and the author suggests the action of comets carrying off portions of the nebulous border of a sun, as they struck it in the direction of its motion at a suitable moment.

The fifth and last article, in the results of which Dr. Smith expresses confidence other than he shows in respect of his earlier excursions into heterodox and quasi-heterodox physics, is devoted to "the laws of river-flow." Residence on the banks of the Mississippi enabled him to discover the formula of a double spiral action, by which to explain the elevation of the middle of a stream, the drift of floating material from the sides and of sunken material to the sides, the shape and depth of the eroded channels, the different speed of diverse portions of the current. This piece of at any rate unborrowed speculation appears not unworthy of consideration. H. W. B.

*Das Heidelberger Schloss und Seine Gärten in alter und neuer Zeit und der Schlossgarten zu Schwetzingen.* By H. R. Jung and W. Schröder. Pp. 74. (Berlin: G. Schmidt, 1898.)

In this work we have an historical account of the gardens and castles of Heidelberg—the famous German university town, and its less well-known neighbour Schwetzingen. The authors are both gardeners, and, although the book is written chiefly from a garden point of view, a good deal of space is given to purely historical matter. Judging from the photographs, the gardens at Schwetzingen seem to be far more beautiful and natural than those of Heidelberg, where grottoes, shrines, and various other architectural devices appear to be the leading features, and not always ornamental ones either. To those interested in the history of very old and famous gardens, this treatise may be of use; and it will not take up much space on the library shelf, being only about a quarter of an inch in thickness. It is well printed and illustrated, and is practically free from misprints; the only one of any importance being at p. 47, where Azalea appears as Aralea. Were it not that there is a genus Aral*i*a, this slip would not be worth mention.

John Weathers.

*Graduated Test papers in Elementary Mathematics.* By Walter J. Wood, B.A. Pp. 71. (London: Macmillan and Co., Ltd., 1899.)

There are forty test-papers in this collection, each containing questions in arithmetic, Euclid, and algebra. At the head of each test are notes stating the parts of the subjects required in order to solve the questions. The papers are primarily intended to test the progress of students preparing themselves for the examination in first stage mathematics of the Department of Science and Art, and Departmental teachers will find them of real value for that purpose. In the lower mathematical forms of secondary schools, also, the papers should be of service, as many of the questions have been selected from the papers of public examining bodies mostly favoured by such schools. Care appears to have been taken in selecting and arranging the questions, and answers are given to all the questions in arithmetic and algebra.

*The Story of the British Race.* By John Munro. Pp. 242. (London: George Newnes, Ltd., 1899.)

Some time ago Mr. Munro wrote "The Story of Electricity" for this library of useful stories. In this volume he transfers his attentions to the science of anthropology, and expresses in his preface the hope that his book will "tend to destroy some errors regarding the origin and pedigree of the nation which have infected life and literature for ages." The volume should be the means of creating an interest in the study of mankind, in addition to imparting a knowledge of the nature of the races in the British Islands.

## LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* Nature *No notice is taken of anonymous communications.*]

### Fourier's Series.

I have M. Poincaré's authority to publish the accompanying note regarding the applicability of Fourier's series to discontinuous functions, and send it accordingly for publication in Nature. A. A. Michelson.

Mon cher Collègue,—Comme je l'avais prévenu vous avez, tout à fait raison. Prenons d'abord l'integrale $\int_0^y \frac{\sin xz}{x} dx$, dont la limite pour $y = \infty$ est $\pi/4$, 0, $-\pi/4$ selon que $z$ est positif, nul ou négatif.

Faisons maintenant tendre simultanément $z$ vers $o$ et $y$ vers l'infini de telle façon que $zy$ tende vers $a$. La limite sera $\int_0^a \frac{\sin x}{x} dx$ qui peut prendre toutes les valeurs possibles depuis o jusqu'à $\int_0^\pi \frac{\sin x}{x} dx$.

Si nous prenons maintenant $n$ termes dans la série $\Sigma \frac{\sin kz}{z}$ en faisant tendre simultanément $z$ vers $o$ et $n$ vers l'infini de telle façon que le produit $nz$ tende vers $a$, cela sera évidemment la même chose; et la différence entre la somme et l'integrale sera d'autant plus petite que $z$ sera plus petit. Cela se voit aisément. Tout à vous,

(Signed) Poincaré.

### A Note upon Phosphorescent Earthworms.

It has been long known that earthworms may be phosphorescent. So long ago as 1836 Prof. Dugès described, under the name of *Lumbricus phosphoreus*, a worm which showed this peculiarity. In 1887 Prof. Giard showed that a worm probably identical with this, and, if so, not a *Lumbricus* at all, was marked luminous, especially when the soil was disturbed in the vicinity. Giard named the species *Photodrilus phosphoreus.* It has been met with and noticed to be luminous by two other observers. Quite recently (*Zoolog. Jahrbücher*, xii., 1899, p. 216) Dr. Michaelsen, of Hamburg, ascertained that this species of Giard is really identical with *Microscolex modestus* of Rosa. The multiplication of names is hardly the fault of Prof. Giard, since the genus *Microscolex* had only been instituted a few months before his genus *Photodrilus.* This species, unlike the majority of its congeners, which are chiefly congregated in Patagonia, and there very abundant, is not only European, but also occurs in England. It seems also to be, at least usually, phosphorescent. I received some time since, through the kindness of Mr. Carleton Rea, a few small earthworms from the neighbourhood of Worcester, which were undoubtedly a *Microscolex*, and at least not much different from *M. modestus.* Mr. Rea informed me that they were phosphorescent, with a "light emitted exactly similar to that of the glow-worm." They could be stimulated to show this light by "stamping the lawn." It has been suggested that this phosphorescence in earthworms is really due to photogenic bacteria entangled in the slime upon the skin. Possibly such an explanation may account for the occasional phosphorescence of *Allolobophora foetida* (the "Brandling"), observed by Vejdovsky. But the regularity, and the mode of excitation, of the luminosity seems to show that *Microscolex* is phosphorescent in its own right.

Frank E. Beddard.

## ON THE CHEMICAL CLASSIFICATION OF THE STARS.[1]

In the attempts made to classify the stars by means of their spectra, from Rutherford's time to quite recently, the various criteria selected were necessarily for the most part of unknown origin; with the exception of hydrogen, calcium, iron, and carbon, in the main chemical origins could not be assigned with certainty to

[1] By Sir Norman Lockyer, K.C.B., F.R.S. A paper read at the Royal Society, May 4.

the spectral lines. Hence the various groups defined by the behaviour of unknown lines were referred to by numbers, and as the views of those employed in the work of classifying differed widely as to the sequence of the phenomena observed, the numerical sequences vary very considerably so that any coordination becomes difficult and confusing.

Recent work has thrown such a flood of light on the chemistry of the stars that most definite chemical groupings can now be established, and the object of the present communication is to suggest a general scheme of classification in which they are employed, in relation to the line of cosmical evolution which I have developed in former papers communicated to the Society.

The fact that most of the important lines in the photographic region of the stellar spectra have now been traced to their origins renders this step desirable, although many of the chemical elements still remain to be completely investigated from the stellar point of view.

The scheme is based upon a minute inquiry into the varying intensities, in the different stars, of the lines and flutings of the under-mentioned substances :—

Certain unknown elements (probably gaseous, unless their lines represent "principal series") in the hottest stars, and the new form of hydrogen discovered by Prof. Pickering (which I term proto-hydrogen for the sake of clearness). Hydrogen, helium, asterium, calcium, magnesium, oxygen, nitrogen, carbon, silicium.

Iron, titanium, copper, manganese, nickel, chromium, vanadium, strontium ; the spectra being observed at the highest available spark temperatures. The lines thus observed I term enhanced lines, and I distinguished the kind of vapour which produces them by the affix proto, *e.g.* proto-magnesium, for the sake of clearness.[1]

Iron, calcium, and manganese at arc temperatures.

Carbon (flutings) at arc temperatures.

Manganese and iron (flutings) at a still lower temperature.

In a communication to the Society[2] I stated the results arrived at recently with regard to the appearances of the lines of the above substances in stars of different temperatures, and the definition of the different groups or genera to be subsequently given are based upon the map which accompanied the paper, together with more minute inquiries on certain additional points, the examination into which was suggested as the work went on.

So far as the inquiry has at present gone, the various most salient differences to be taken advantage of for grouping purposes are represented in the following stars, the information being derived from the researches of Prof. Pickering[3] and Mr. McClean,[4] as well as from the Kensington series of photographs.

*Hottest Stars.*

Two stars in the constellation Argo (ε Puppis and γ Argûs).[5]

Alnitam (ε Orionis). This is a star in the belt of Orion shown on maps as Alnilam. Dr. Budge has been good enough to make inquiries for me which show the change of letter to have been brought about by a transcriber's error, and that the meaning of the Arabic word is "a belt of spheres or pearls."

*Stars of intermediate Temperature (Ascending Series).*

β Crucis, ε Tauri, Rigel, α Cygni, [ ] Polaris, Aldebaran.

[1] *Roy. Soc. Proc.*, vol. lxiv. p. 398.
[2] *Roy. Soc. Proc.*, vol. lxiv. p. 396.
[3] *Astro.-Phys. Journ.*, vol. v. p. 92, 1897.
[4] "Spectra of Southern Stars."
[5] The spectrum of this star contains bright lines, but I show in a paper nearly ready for communication to the Society, that when these occur with dark lines, the latter alone have to be considered for purposes of chemical classification.

*Stars of intermediate Temperature (Descending Series).*

Achernar, Algol, Markab, [ ] Sirius, Procyon, Arcturus.

*Stars of lowest Temperature.*

| *Ascending Series.* | *Descending Series.* |
|---|---|
| Antares, one of the brightest stars in Duner's observations of Class III*a*.[1] | 19 Piscium, one of the brightest stars in Duner's Class III*b*. |
| [Nebulæ.] | [Dark Stars.] |

In order to make quite clear that both an ascending and a descending series must be taken into account, I give herewith two photographs showing the phenomena observed on both sides of the temperature curve in reversing layers of stars of nearly equal mean temperatures, as determined by the enhanced lines. The stars in question are :—

Sirius (descending).
α Cygni (ascending).

Procyon (descending).
γ Cygni (ascending).

The main differences to which I wish to draw attention are the very different intensities of the hydrogen lines in Sirius and α Cygni, and the difference in the width and intensities of the proto-metallic and metallic lines in Procyon and γ Cygni.

These differences, so significant from a classification point of view, were first indicated in a communication to the Society in 1887,[2] and the progress of the work on these lines has shown how important they are.

I have based the group—or generic—words upon the following considerations.

As we now know beyond all question that a series of geological strata from the most ancient to the most recent brings us in presence of different organic forms, of which the most recent are the most complex, it is natural to suppose that the many sharp changes of spectra observed in a series of stars from the highest temperature to the lowest brings us in presence of a series of chemical forms which become more complex as the temperature is reduced. Hence we can in the stars study the actual facts relating to the workings of inorganic evolution on parallel lines to those which have already been made available in the case of organic evolution.

If then we regard the typical stars as the equivalents of the typical strata, such as the Cambrian, Silurian, &c., it is convenient that the form of the words used to define them should be common to both ; hence I suggest an adjectival form ending in *ian*.

If the typical star is the brightest in a constellation, I use its Arabic name as root ; if the typical star is not the brightest, I use the name of the constellation.

The desideratum referred has to a certain extent determined the choice of stars where many were available. I have to express my great obligations to Dr. Murray for help generously afforded in the consideration of some of the questions thus raised. The table runs as follows :—

*Highest Temperature, Simplest Chemistry.*

Argonian.
Alnitamian.

| *Ascending Series.* | *Descending Series.* |
|---|---|
| Crucian. | Achernian |
| Taurian. | Algolian |
| Rigelian. | Markabian |
| Cygnian. | —— |
| —— | Sirian. |
| Polarian. | Procyonian. |
| Aldebarian. | Arcturian. |
| Antarian. | Piscian. |

The chemical definitions of the various groups or genera are as follows :—

[1] "Sur les étoiles à spectres de la troisième classe."
[2] *Roy. Soc. Proc.*, vol. lxi. p. 182.

*Argonian.*

*Predominant.*—Hydrogen and proto-hydrogen.

*Fainter.*—Helium, unknown gas (λ 4451, 4457), proto-magnesium, proto-calcium, asterium.

*Alnitamian.*

*Predominant.*—Hydrogen, helium, unknown gases (λ 4089·2, 4116·0, 4649·2).

*Fainter.*—Asterium, proto-hydrogen, proto-magnesium, proto-calcium, oxygen, nitrogen, carbon.

*Crucian.*

*Predominant.* — Hydrogen, helium, asterium, oxygen, nitrogen, carbon.

*Fainter.*—Proto-magnesium, proto-calcium, unknown gas (λ 4089·2), silicium.

*Achernian.*

Same as Crucian.

Proto-metallic lines relatively thick, hydrogen relatively thin.

*Taurian.*

*Predominant.*—Hydrogen, helium, proto-magnesium, asterium.

*Fainter.* — Proto-calcium, silicium, nitrogen, carbon. oxygen, proto-iron, proto-titanium.

*Rigelian.*

*Predominant.*—Hydrogen, proto-calcium, proto-magnesium, helium, silicium.

*Fainter.*—Asterium, proto-iron, nitrogen, carbon, proto-titanium.

*Cygnian.*

*Predominant.*—Hydrogen, proto-calcium, proto-magnesium, proto-iron, silicium, proto-titanium, proto-copper, proto-chromium.

*Fainter.* — Proto-nickel, proto-vanadium, proto-manganese, proto-strontium, iron (arc).

*Polarian.*

*Predominant*—Proto-calcium, proto-titanium, hydrogen, proto-magnesium, proto-iron, and arc lines of calcium, iron, and manganese.

*Fainter.*—The other proto-metals and metals occurring in the Sirian genus.

Proto-metallic lines relatively thin, hydrogen relatively thick.

*Algolian.*

*Predominant* —Hydrogen, proto-magnesium, proto-calcium. helium, silicium.

*Fainter.* — Proto-iron, asterium, carbon, proto-titanium, proto-copper, proto-manganese, proto-nickel.

*Markabian.*

*Predominant.*—Hydrogen, proto-calcium, proto-magnesium, silicium.

*Fainter.*— Proto-iron, helium, asterium, proto-titanium, proto-copper, proto-manganese, proto-nickel, proto-chromium.

*Sirian.*

*Predominant.*—Hydrogen, proto-calcium, proto-magnesium, proto-iron, silicium.

*Fainter.*—The lines of the other proto-metals and the arc lines of iron, calcium, and manganese.

*Procyonian.*

Same as Polarian.

*Aldebarian.*

*Predominant.* — Proto-calcium, arc lines of iron, calcium, and manganese, proto-strontium, hydrogen.

*Fainter.* — Proto-iron and proto-titanium.

*Arcturian.*

Same as Aldebarian.

*Antarian.*

*Predominant.* — Flutings of manganese.

*Fainter.*—Arc lines of metallic elements.

*Piscian.*

*Predominant.*—Flutings of carbon.

*Fainter.* — Arc lines of metallic elements.

We may take for granted that as time goes on new intermediate genera will require to be established; the proposed classification lends itself conveniently to this, as there are no numerical relations to be disturbed.

A still more general chemical classification is the following, it being understood that in it only the most predominant chemical features are considered, and that there is no sharp line of separation between these larger groups. The peculiar position of calcium and magnesium render this caveat the more necessary.

Highest temperature.

| | | | |
|---|---|---|---|
| Gaseous stars | Proto-hydrogen stars | Argonian.<br>Alnitamian. | |
| | Cleveite gas stars | Crucian.<br>Taurian. | Achernian.<br>Algolian. |
| Proto-metallic stars | | Rigelian.<br>Cygnian.<br>— | Markabian.<br>—<br>Sirian. |
| Metallic stars | | Polarian.<br>Aldebarian. | Procyonian.<br>Arcturian. |
| Stars with fluted spectra | | Antarian. | Piscian. |

Lowest temperature.

The detailed chemical facts to be gathered from the definitions of the several genera indicate many important differences between the order of appearance of chemical substances in the atmospheres of the stars and that suggested by the hypothetical "periodic law." Special investigations are in progress by which it is hoped some light may be thrown on this and other points of a like nature.

## THE USE OF PHOSPHORUS IN THE MANUFACTURE OF LUCIFER MATCHES.

OUR readers will be aware that about a year ago the attention of the public was specially directed to the danger which attends the use of yellow phosphorus in the manufacture of matches. Numerous cases of necrosis of the jaw were reported, and some of these occurred in factories which were supposed to be conducted on hygienic principles. There were also some cases in these factories which had been intentionally concealed from the proper authorities. The Home Office accordingly requested Profs. Thorpe and Oliver to inquire and report upon the subject, and shortly afterwards these authorities were joined by Dr. Cunningham, senior dental surgeon to the London Hospital, in view of the importance of the practical dental question at issue.

These three gentlemen have now presented their report, and it has been issued (January 1899) as a Blue Book of 236 pages. It is to be hoped that the Government will see their way to act promptly on the recommendations here set forth, and that by a proper system of inspection they will provide for the carrying out of the new regulations; many excellent rules for the management of match factories already exist, but in some cases these have become practically a dead letter, as they have not been enforced sufficiently stringently.

We have nothing but praise for the way in which the three investigators have carried out their work. Prof. Thorpe deals with the question from the chemical standpoint, and enters into such matters as the differences between the allotropic forms of phosphorus, the composition of phosphorus fumes, their solvent action on teeth, and the composition of the various pastes, &c., used in the manufacture of matches. Full and illustrated accounts of the process of manufacture are given, both in this and in other countries, and the precautions taken to minimise the danger to the workpeople. Dr. Oliver, whose work in connection with other dangerous trades is so well known, approaches the question from

the medical standpoint, and the portion of the report for which he is responsible is clear, concise, and intensely practical. Dr. Cunningham's report contains a full account of phosphorus necrosis, and is illustrated by diagrams showing various stages of the disease in the teeth and jaws. This condition is the most frequent and most obvious of the poisonous effects of phosphorus; it is not by any means the only one. He also gives in full the precautions which should be adopted in all factories for combating the injurious effects of the poisonous fumes. There are various appendices which give in detail the facts upon which the main body of the report is founded.

The whole report is a clear evidence of the painstaking way in which the Commission has carried out of its work, and is specially valuable, seeing that the investigators have visited various foreign countries in order to compare what is being done there with what occurs in our own country. An admirable summary of conclusions is furnished by Dr. Arthur Whitelegge, the chief inspector of factories. The main conclusions are as follows:—

In the match industry two forms of phosphorus are used: *yellow phosphorus*, which is highly poisonous, and gives off poisonous fumes which consist mainly of low oxides of phosphorus; and *red phosphorus*, which does not fume, and is hardly poisonous even if swallowed.

Then, as is well known, there are two principal varieties of matches used: the "safety matches," which are tipped with a composition free from phosphorus; the surface on which they strike is covered with a composition of which red phosphorus forms a part. The "strike anywhere" matches are tipped with a paste containing yellow phosphorus in a proportion which varies from 3 to 30 per cent.; but in this country not more than 6 or 7 and often less than 5 per cent. is used. It is in the making of such matches only that danger arises. Attempts are being made to make "strike anywhere" matches which contain no yellow phosphorus, and rewards have been offered for an effective match of this kind, but up to the present these efforts have not been successful; either such matches do not strike anywhere, or else they are violently explosive.

The specially dangerous processes in the manufacture of matches containing yellow phosphorus are *mixing* the paste, *dipping* the wood or wax stems, *drying* the bundles after dipping, and *boxing* the dried matches; it is the last process which involves the most handling of the matches.

The rules that already exist require (1) natural and mechanical ventilation to be efficient in the rooms where these processes are being carried out; (2) effectual means to prevent the fumes entering other parts of the factory; (3) that no person shall be employed who has suffered from necrosis, or had a tooth extracted; (4) that persons suffering from toothache shall be at once medically examined; (5) notification of cases of necrosis is obligatory; and (6) proper conveniences for washing shall be provided.

Both here and abroad many firms have done a good deal more than this: the dental supervision has been efficient, and the introduction of elaborate machinery instead of hand labour in the four dangerous processes has done more than anything else to lessen the danger. In some foreign countries the precautions taken are in advance of our own, but in this country special praise is given to the Diamond Company's factory at Liverpool, where cases of phosphorus necrosis have never occurred. In Germany, Austria, and Switzerland, there is, however, the surreptitious manufacture of matches as a home industry to be contended with; this disastrous practice has, happily, not been attempted in Great Britain.

The main point which the Commission had to decide was undoubtedly whether they should recommend the use of yellow phosphorus to be prohibited. We may give their decision in their own words:—

"So far as the home consumption is concerned, it does not seem that the prohibition of the use of yellow phosphorus would involve any serious hardship, and this course has already been adopted by Denmark, and decided upon by Switzerland, care being taken at the same time to prohibit the use or importation of yellow phosphorus matches. But neither of these countries has or had any export trade to lose. The United Kingdom, Belgium, Sweden, and Japan, manufacture largely for export,[1] and it is feared that immediate prohibition of yellow phosphorus would at once divert that portion of our trade to other countries, unless international agreement upon the subject was arrived at. If grave injury to the health of the workpeople were inevitable, the loss of the trade might well be regarded as the smaller sacrifice of the two, but the result of the inquiry points to a different conclusion. With due selection of workpeople, strict medical and dental supervision, proper structural and administrative conditions, and substitution of machinery for hand labour, it seems that the dangers hitherto attending the use of yellow phosphorus can be overcome."

We need not go into the details of all the precautions set forth; they will involve revision of the present rules, and put briefly they consist of absolute cleanliness, perfect ventilation, medical selection of workpeople (children, debilitated persons, and those with unsound teeth being excluded), compulsory dentistry, substitution of machinery for direct handling, and limitation of the percentage of phosphorus in the paste.

We learn that in Russia a tax is imposed upon the manufacture of yellow phosphorus matches, with the result that safety matches are displacing the "strike anywhere" kind. The Commissioners make no recommendation that a similar tax should be imposed here; they are also silent in regard to recommendations concerning international agreement in view of the total prohibition of the use of yellow phosphorus. No doubt this would have been the most stringent and the most effective course to adopt. But legislation is a slowly moving machine, and international legislation a more cumbrous one still. Recognising this, the report suggests what is a more practical remedy, and certainly a more immediate one. What has been accomplished by the Diamond Factory at Liverpool should be made compulsory elsewhere, and for the sake of the workers it is to be hoped that there will be no delay in carrying the suggested rules into operation.

## *MIMICRY AND WARNING COLOURS.*[2]

IT is just twenty years ago since the late Charles Darwin called the writer's attention to a little paper, by Fritz Müller, published in *Kosmos* for May 1879, and containing a new suggestion concerning the theory of mimicry. It was the writer's misfortune to have foreseen that the principle discovered by Müller was likely to exert a profound influence on certain biological problems of which the solution had up to that time been unattempted, and he accordingly introduced the new idea to the entomologists of this country by inserting a translation of the paper in the *Proceedings* of the Entomological

[1] For foreign and colonial use, especially in hot and humid climates, the yellow phosphorus matches keep better and resist damp.

[2] "Natural Selection the Cause of Mimetic Resemblance and Common Warning Colours." By Edward B. Poulton, M.A., F.R.S. (*Journ. Linn. Soc. Zoology*, vol. xxvi. pp. 558–612.)

Society of London. The misfortune lay in the circumstance that the entomologists of that time were unprepared for new ideas, and the writer had accordingly to incur the opprobrium of an innovator. He has happily survived this treatment, but how far any advancement has been made by entomologists since the year 1879 may be gathered from the discussion of the whole subject which was raised in the Entomological Society in 1897, and of which a summary is given by Prof. E. B. Poulton in the paper now under consideration. So far as the writer of this notice is concerned, the first gleam of encouragement came from Dr. Alfred Russel Wallace, who, with his well-known power of mental penetration, had no sooner had the case submitted to his judgment than he accepted the new doctrine, and incorporated it in his book on "Darwinism." From the discussion of 1897 it appears that the majority of our entomologists are still hostile to the Müllerian theory; but conspicuous among those who have helped to support and develop it is the author of the paper now before us. We may claim also Dr. F. A. Dixey, of Oxford; Mr. Roland Trimen, one of the early pioneers with Bates and Wallace in the subject of mimicry; Colonel Swinhoe; Dr. A. G. Mayer, of America; Mr. Gahan, of the British Museum, and some few others, as co-heretics in this later development of the theory of mimicry.

The original theory propounded by Bates in 1861 is so well known, and has been so frequently discussed in these columns, that it is unnecessary to restate it. The fundamental condition is that the imitated form should be objectionable to insectivorous enemies, while the mimic should not be protected by any distasteful qualities. The Müllerian theory, briefly stated, is that two or more species belonging to distasteful groups will derive benefit from mimetic resemblance because, although immune as compared with non-protected species, they are not altogether exempt from persecution, and the loss in individuals incurred by each mimetic species becomes proportionally more and more diminished the larger the number of indivduals over which the loss is distributed. Thus the resemblance being advantageous can be conceived to have been brought about by natural selection in the Müllerian mimicry in precisely the same way that it has been conceived to have been brought about in the Batesian mimicry. Whether it has actually been so brought about, is just the point about which there has been so much discussion; but if natural selection plays any part at all in species formation—and the writer still finds himself in the position of being without any other adequate theory—then a perusal of Prof. Poulton's paper, and the powerful arguments which he has marshalled therein, cannot fail to convince the unprejudiced naturalist that if natural selection was valid for Bates it is equally valid for Müller, and, further, that if natural selection is inadequate in either or both cases, then we have no theory of mimicry that will at all bear critical examination, and the whole body of facts remain as inexplicable as in pre-Darwinian times.

The method adopted by Prof. Poulton in the present paper is that of exclusion. He discusses all the alternative explanations which have been suggested, and finds them to be untenable when submitted to close analysis. There is thus left only the theory of natural selection The competing theories are all resolvable into three—viz. (1) external action of environment (2) independent development along similar lines by internal causes, and (3) psychical influence of predominating types of colour and pattern leading to the sexual selection of that type. The latter theory is not very likely to survive, although Mr. Darwin in 1872 wrote to the writer of this notice: "I do not feel at all sure that this view is as incredible as it may at first appear." It should be added that the said suggestion also came from Fritz Müller in a letter to Darwin. Rejecting for the present No. 3, the author deals at length with Nos. 1 and 2. Before marshalling the facts it is, however, considered necessary to insist that the resemblances herein dealt with are part and parcel of the general phenomenon of Protective Resemblance. This point is strangely put into the background, or altogether ignored, by the upholders of non-Darwinian theories of mimicry, and Prof. Poulton has done good service in bringing it well to the front again. It is surprising that the two sets of facts, viz. resemblance to environment and resemblance to other living species, should be dissociated, in spite of the circumstance that Bates and Wallace and most writers on the subject since have distinctly recognised the fundamental importance of grouping them together. It is, of course, inconvenient to the opponents of the Darwinian explanation to admit that resemblances to bark, leaves, twigs, &c., which are so well explained by natural selection, should be of the same order as a set of resemblances for which that explanation is regarded as indequate. And even if it is allowed that protective resemblance and the old (Batesian) mimicry are due to natural selection—as some of the speakers seemed to admit in the discussion of 1897—the extension to the newer (Müllerian) mimicry is opposed by either ignoring or denying the facts, or by substituting untenable theories.

The original theory of Müller was limited in its application to certain butterflies (*Ituna* and *Thyridia*) which were not very remote in their kinship, but in which the superficial resemblance was too exact to admit of explanation by blood-relationship alone. In 1882 the writer of this notice, in a paper published in the *Annals and Magazine of Natural History*, ventured upon an extension of the Müllerian principle to whole groups of related and "protected" species in which a general similarity in the type of pattern and colouring prevails. The idea was that the abstract type of marking became associated with a knowledge of inedibility in the mind of insectivorous enemies. Five years later (*Proc. Zool. Soc.*, 1887), the author of the paper now before us made a further advance by extending the Müllerian principle to large groups of insects quite unrelated by affinity, and belonging, in fact, to different orders. It is only necessary to bring together an assemblage of species belonging to different orders, and having a general superficial resemblance among themselves, to constitute a presumptive case of "Müllerian association." If it can be shown that this group of species is for one reason or another more or less exempt from persecution as compared with non-protected species, the case would at once become Müllerian as distinguished from Batesian. It is, of course, doubtful in many cases to which class a particular example of mimicry may belong. The result of the recent work of Poulton, Dixey and Mayer is to make it appear probable that the Müllerian principle is of more widespread importance in nature than the older principle of Bates.

Since the superficial resemblance of insects belonging to distinct orders, such as a moth to a wasp or beetle, a beetle to an ant, and so forth, cannot have been aided at the outset by blood-relationship, the result in all cases where the association is Müllerian, whether attributed to natural selection or to any other cause, can only have been brought about by a process of convergence. The essence of the Müllerian principle also is that the so-called protected species are subject to a certain percentage of extinction, and the resemblance which we now find among them is accordingly advantageous, in the same sense that a distasteful caterpillar is gorgeously coloured according to Wallace's well-known theory. For this reason Prof. Poulton prefers to limit the term mimicry to the Batesian principle; the Müllerian cases are described

in the present paper as "common warning colours, and the author proposes for them the term *synaposematic*.

Not the least satisfactory feature of the present summing up of the position by Prof. Poulton is the distinct convergence of the evidence in favour of the natural selection theory which has been accumulated since 1879. The sacrifice of a certain percentage of individuals to the inexperience of their enemies was an assumption on Müller's part, and the present writer well remembers pointing out in a letter to that eminent naturalist that his case would be enormously strengthened if he would make observations on the spot. The result was a long series of a distasteful *Acraea*, collected by Müller in order to show that bird-pecked wings were of frequent occurrence. Much evidence of the same kind has been since obtained, and a most valuable series of experiments conducted by Mr. Finn, in India, during the years 1895-96-97, and published in the *Journal* of the Asiatic Society of Bengal, have led that author to the conclusion that unpalatable forms are by no means altogether free from attack.

It must be further borne in mind that in 1879 the question of the non-transmission of acquired characters had not been brought into prominence. It was tacitly assumed in the theory of Bates that a knowledge of edible and inedible types could be transmitted by heredity. It is remarkable that Müller, by virtue of his hypothesis, should have unconsciously challenged this tacit assumption by suggesting that young birds had to learn by experience, and did not derive their knowledge of eatable and distasteful forms by heredity. The whole tendency of Prof. Lloyd Morgan's work of late years has been to confirm this suggestion by actual observation and experiment; and Mr. Finn, also, in summing up his results, states that "each bird has to separately acquire its experience, and well remembers what it has learned." Thus the Müllerian theory of 1879 has now been placed on a psychological basis of well-ascertained facts.

Those who still believe that common warning colours can be explained by internal or external causes, as defined in the present paper, will, we imagine, find the ground crumbling away from beneath their feet if they will seriously weigh the arguments set forth by Prof. Poulton. What series of external causes in nature are there, for example, which can so act upon an organism as to modify only those superficial characters which are required to bring about a resemblance to another form while leaving all other characters unmodified? To attribute such modification to independent evolution by virtue of innate tendencies or laws of growth or internal forces, appears to the writer to be substituting mysticism for scientific explanation. What external agencies can be conceived which shall, while acting without visible result upon the early stages of all kinds of insects, culminate only in a resemblance between the imagos? The external conditions of life are imposing themselves during the whole of the larval and pupal existence, and yet these forms remain quite distinct, while the imagos come forth at once with all their disguising characters perfected.

On considering again the undoubted fact that in many cases of mimicry and common warning colours the female only is affected, the inadequacy of any explanation depending on direct action of environment or internal evolutional "tendencies" becomes strikingly apparent. So also, as Prof. Poulton illustrates by a most remarkable set of examples, when insects of different orders resemble each other, the superficial similarity must necessarily be brought about by the most diverse kinds of modification of parts. To attribute such distinct and diverse modifications of form, directed towards a common end, to similarity of external forces or internal tendencies, seems to the writer to be a straining of hypothesis beyond any degree of rashness attributed to the supporters of natural selection. What natural agency can be imagined that will account for the production of a similar colour in two or more species—in one form by developing pigment, and in another by developing striation of surface, so as to produce the same chromatic effect, excepting selection which works only for advantageous results irrespective of means? Even within the same order, where the resemblances might be more reasonably supposed to be due to similarity of external conditions, the likeness is superficial only, and is brought about by the most diverse means. There is apparently no chemical relationship between pigments which produce the same visual effect in mimetic butterflies of different families. A visual resemblance is required only by natural selection; external and internal causes have been incompetent in such cases to modify the more deeply concerned physiological processes so as to produce similarity of appearance by identity of pigment. Such a character as transparency of wing, also, is shown to have been attained by several distinct methods; by reduction in the number of scales, by reduction in their size, by loss of pigment, by being set up on edge instead of lying flat, and so forth. Any common set of forces, external or internal, which can bring about the same result, viz. wing transparency, by such diverse methods is simply inconceivable.

We have given only a few illustrations of the arguments which the author makes use of in this paper to dispose of the theories which have been advanced by way of substitutes for natural selection. As Prof. Poulton says in conclusion: "The review of the whole subject during the past thirty-six years increases our confidence in the theories of Bates and Fritz Müller, while it disposes of all alternative hypotheses."

It should be added that many new examples of mimicry and common warning colours—some of them of the most striking character—are given in the paper. More particularly will English entomologists be interested in the resemblance of the young larvæ of *Stauropus fagi* to an ant, and of the similarity in appearance and habit of the young larvæ of *Endromis versicolor* to saw-fly larvæ.

R. MELDOLA.

## PROFESSOR CHARLES FRIEDEL.

FRANCE has lost one of her most distinguished chemists in the person of Prof. Charles Friedel, member of the Institute, who died at Montauban on April 20. He was born in Strassburg on March 12, 1832. His father was a banker; his mother was the daughter of Dr. Duvernoy, well known in his day as a scientific man. He distinguished himself so greatly in his studies that he took his degree of Bachelor of Science with special honours. Desiring to follow science as his profession he went to Paris, and gained the special esteem of M. de Sénarmont, who caused him to be appointed conservator of the mineralogical collections at the École des Mines. He worked in the laboratory of the distinguished chemist M. Adolph Wurtz, also a native of Alsace, at the École de Médecine. In 1856 he married Miss Kœchlin, by whom he had five children, one of whom, George Friedel, is known as a professor at the mining school of St. Etienne. Mrs. Friedel died in 1871, at Vernex, where she had retired during the Franco-German war; and her husband, who was shut up in Paris, knew nothing of the sad event until after the city capitulated. He was married again, in 1873, to Mlle. Louise Combes, whose father was a member of the Institute of France, and who, with their son and a large circle of relations, now mourn his recent decease. To return to his professional distinctions: in 1869 he became Doctor of Science; two years after he received a high appointment at the École Normale Supérieure. In 1876 he became Professor of Mineralogy at the Faculté des Sciences, at the Sorbonne; and in 1878 he received the

distinguished honour of membership of the Institute (Academie des Sciences). In 1884 he took the position of his late master, Prof. Wurtz, in the chair of Organic Chemistry at the Sorbonne. His merits were fully recognised in this country. In 1876 he became a foreign member of the Chemical Society, and four years later he received the Davy Medal of the Royal Society. In 1894 he made one of his rare visits to England to receive the degree of D.C.L. of Oxford University, an honour which he acknowledged as a great encouragement.

His influence on the advance of science was of a two-fold character: as a teacher, and as an original investigator. He was not known as a popular lecturer or writer upon science; but he had the happy faculty of infusing the love of science into the minds of the large number of students who attended his professorial lectures or worked in his laboratory. This result was no doubt greatly enhanced by the respect and personal attachment with which he was regarded. The advancement of education was in fact one of the objects of his life. This was evidenced by the successful efforts he made in promoting the École Alsacienne in 1874, which, to use his own words, was "designed to react against the exclusively literary and formal instruction, and directed in a Protestant and Christian spirit, without having any denominational colour." Its aim was to develop in each scholar the faculties which belong to him, and to arouse a spirit of observation and scientific curiosity. Natural science has, of course, an honoured place in the curriculum. He watched over this school with great interest, and helped to make it one of the best in the capital of France. The technical side of science also engaged his attention; and he had a large share in founding at Paris, three years ago, a laboratory of practical chemistry applied to industry, at the Sorbonne, and to which he gave special attention. He was one of the founders of the French Chemical Society. It is said also that the French Association for the Advancement of Science owes its origin to his suggestion; at any rate he came to the meeting of the British Association at Brighton in 1872 to learn the details of its working, for the benefit of the French Association which was to be inaugurated at Bordeaux in September of that year. The two Associations, though very different in their constitution, are carried on in much the same manner. M. Friedel generally took an important part in the French Association's annual meetings. In the last of the numerous letters that I received from him, he made reference in hopeful terms to the approaching meetings of the two Associations at Dover and Boulogne in September next, and to the efforts which were in contemplation to bring together the savants of the two nations.

Throughout the whole of his career he carried on original research, the results of which are published in about one hundred papers communicated to the Academy of Sciences and other learned societies. Some of these refer to the artificial formation of felspar and albite, crystallised quartz and other minerals, and to the dimorphism of zinc blende; but by far his most important work has reference to the carbon compounds, and the long controversies which raged over the question of their constitution, and how it should be expressed. His first paper seems to have been a contribution, in 1857, bearing on the constitution of acetone. This was followed by others on lactic acid, glycerine, propylene and other members of the three-carbon family. The relation of these bodies one to another, and to their isomers, led to much fruitful controversy. To him, in fact, is due in great measure the introduction of the new views of atomic valency, of which the chief apostles were Cannizzaro and Kekulé. In France these ideas were not readily received; the chief advocacy of them came from the laboratory of Wurtz, and although Friedel had not the enthusiasm and brilliancy of the master, his expositions and arguments were wonderfully clear, and his experiments in support of them very convincing. Among these was the production, in conjunction with Ladenburg and Crafts, of a number of compounds of silicon and titanium showing the quadrivalence of these elements and their chemical analogy with carbon. In this way they broke down the barriers between organic and inorganic chemistry, and showed the generality of the laws of chemical combination. During these researches he was fortunate in discovering a new method, by means of chloride of aluminium, of bringing about the synthesis of organic compounds, often producing hydrocarbons of a highly complex character.

With the rapid advance of chemical knowledge, especially in the organic department, and the gradual growth of chemical theory, the nomenclature was found to be inexact and often misleading. Hence in 1892 a congress of chemists was held in Geneva to revise the nomenclature. Leading representatives of chemical science from many countries met together, and Friedel was appointed president. The recommendations arrived at were published in Wurtz's Dictionary of pure and applied chemistry, which was carried on under the direction of Friedel.

But he did not confine his work to scientific teaching and investigation. Born in a Protestant family, he seems from his youth to have adopted the religious principles in which he was brought up. He sympathised with all Christian, philanthropic or patriotic movements of his country, and took an active part in many of them, especially those that related to the welfare of young men. Those of us who knew him intimately will feel disposed, like the President of the Academy in announcing his death, to dwell not so much on his great scientific achievements as on the amiability and uprightness of his character and on the moral worth of his personality.

J. H. GLADSTONE.

## *CHARLES NAUDIN.*

CHARLES NAUDIN, whose contributions to science extend over the last sixty years, died on March 19, at Antibes, at the age of eighty-four. A systematist by his studies of the orders *Melastomaceae* and *Cucurbitaceae*, a biologist by his work on hybrids, he is perhaps best known by many contributions to economic botany.

The bravery with which he met the hardships of his life wins admiration. His father, a schoolmaster, ruined himself; his mother died when he was but eight years old. At Montpellier, while working for a degree, he served as usher in small establishments: the degree gained, he became a teacher at Château-Chinon, then at Cette. In 1839 we find him at Paris earning his living by teaching, by copying commercial letters, and lastly as a gardener at the Jardin des Plantes, burning the midnight oil in order to obtain his licentiate in 1841 and the degree of Doctor of Science in 1842.

After helping Saint-Hilaire with his flora ot South Brazil, Naudin became professor of zoology at the Collège Chaptal. But, when success seemed assured, severe facial neuralgia and an incurable deafness, worse than the neuralgia, cut him off from free communion with his fellow-men. Forced back from his course, he applied himself again to herbarium-work, and the study of the *Melastomaceae*—an order richly represented in Brazil—gave him employment till 1849.

Five years later Decaisne made him his aide-naturaliste, and under his stimulus Naudin commenced the experiments on hybrids which secured his reputation. Darwinism had disturbed science; and Decaisne, who, like others, was asking what are species, had commenced to experiment on variability with admirable patience by growing pears from seed. Naudin chose the Gourd

family for like experiments on the variability of hybrids, in doing which he came face to face with difficulties in classification needing the eye of a systematist. How these were met, Sir Joseph Hooker, whom he helped in dealing with this order for the *Genera Plantarum*, and others testify. It is clear that if he multiplied names unduly, he still grouped naturally and truly the allied forms. In the question of hybridity he emphasised abundantly the fact that hybrids frequently have a varying measure of fertility, stating at the same time that in varying they return to the parent forms, and for that reason fail to establish their race—a contention which led to a long controversy.

At this period his work as a gardener came into fruit: the *Manuel de l'amateur des jardins*, and a connection with the *Revue Horticole*, *Flore des Serres* and *Le bon Jardinier* testify to it. But the neuralgia increased, and drove him to seek an asylum away from work in the Pyrenees, whence in 1878 he was called to take charge of the experimental station known as the Villa Thuret at Antibes.

There, in the pleasant climate of the Mediterranean shore, he experimented in the acclimatisation of such plants as were suitable. Algeria, among French Colonies, needed improved cultivation; and the exigence of Algeria called his attention to the vegetation of dry countries. From Australia he grew *Eucalypti* and *Chenopodiaceae;* from South Africa he experimented with *Acanthosicyos;* and the flowering and fruiting and hybridisation of palms interested him strongly. To these experiments on Australian plants is doubtless due his connection with Sir Ferdinand von Mueller, which led to a joint *Manuel de l'Acclimateur*.

This must suffice to indicate the direction of his work—work for which the French-speaking people feel a keen gratitude. To us, it is interesting to recall that a few of his later notes appeared in our language in the *Gardeners' Chronicle*, while two of his earlier papers were considered of sufficient importance to merit translation.

I. H. B.

## THE NEW BUILDINGS AT SOUTH KENSINGTON.

THE foundation stone of the new extension of the Art Museum at South Kensington was laid by Her Majesty the Queen yesterday. When completed, the Museum will be one of the most imposing structures in London, so far as size is concerned. It will have a frontage on Cromwell Road of 700 feet—almost precisely the same frontage as that of the Natural History Museum—and in the Exhibition Road there will be a frontage of 300 feet. The area of the new buildings will be equal to the whole of that covered by the existing Museum, including the temporary sheds on the west side of Exhibition Road.

The Art Museum thus completed is to be called the Victoria and Albert Museum.

The commencement of the new buildings does not directly concern us except that they are complementary to other buildings to be provided for Science on the ground facing the Imperial Institute. It has generally been understood since the Report of the Duke of Devonshire's Commission, which sat about a quarter of a century ago, that a Science Museum was to be built upon this ground. This being so, the building scheme might appropriately have included an Albert Museum for Science as well as a Victoria Museum for Art. But no provision has been made for such a new Science Museum.

According to the *Times*, the centre of the building which it is proposed to place opposite the Imperial Institute will be occupied by the Science Library, and in the plan given by the *Times* the proposed buildings are called "Royal College of Science." But this is not so. The remainder of the frontage will be taken up by chemical and physical laboratories alone; the other departments of the Royal College of Science—astronomical physics, geology, biology, mechanics, mining and metallurgy—will apparently be left in the same unorganised condition as exists at present. It is indeed generally imagined, and it may even be the view of the Chancellor of the Exchequer, that the new buildings are to accommodate all the departments of the Royal College of Science.

We read, for instance, in Tuesday's *Times*:—

"As regards the Royal College of Science, it will, as already indicated, occupy a position directly facing the Imperial Institute. It is to be of the same length as the Institute, and, in the interests of architectural harmony, it will reproduce several of its leading features. The College will be recessed from the road in the same way; the main entrance of the one will be opposite that of the other, and will be so rounded that between the two a large circular space will be left—in the centre of which a statue may be erected later on—the circle being flanked by the great buildings on each side. The domes or lodges at each extreme of the Imperial Institute will be repeated at corresponding points of the College, and the respective sets connected by a screen across the roadway, thus facilitating passage from one side to the other. The new College of Science will also form a front to the present Science Museum buildings, but there is no idea of the College forming in itself an additional "museum" in the recognised sense of that term. It will rather be devoted to strictly educational purposes, the right wing being occupied by the physical side of the College and the left by the chemical department, while the great laboratories and lecture theatres are to be in the rear, the whole being, further, in direct connection with the present Science Museum."

We repeat, the new so-called "College of Science" will represent only a small portion of the College. That the teaching of some of the subjects now carried on in buildings almost half a mile apart, gains nothing from the new scheme, might perhaps have been borne if it were perfectly certain that ultimately all the teaching would be brought together. But unfortunately this is now very much more unlikely than it has ever been before, unless the Science Museum is to be encroached upon, and its future possibilities of extension for ever wrecked; and the more the architectural effect is to be enhanced by recessing the new buildings from the road, the more, naturally, will the space difficulty be increased for College and Museum alike. We have heard that the plans prepared by the Professors of the Royal College themselves some years ago left the central portion clear primarily for the Museum suggested by the Duke of Devonshire's Commission, the chemical and physical laboratories having their frontage along Prince's Gate. That scheme was far preferable to the present one, so far as providing for the other requirements of both College and Museum are concerned.

In any case it must be acknowledged that the building of the chemical and physical laboratories is only a first step. We shall be glad to know that the future has been considered; and that there already exists a plan showing the condition of things when subsequent stages have been reached, even up to the final one. But we very much doubt whether it has been any one's business to consider any of these things, and responsibility is divided among so many departments that it is scarcely to be wondered at if the future has never been considered at all. But there is one thing greatly to be feared, and it is this. Not only does the plan to be carried out leave the greater part of the teaching in a chaotic state with no chance of betterment while the new buildings are going on; but when they are completed, some future Chancellor

of the Exchequer may decline further aid on the ground that no representation was made in the present year pointing out the exact state of the case.

It is apparently one of the prices we have to pay for the long neglect of Science in this country, and its small representation among those in political office, that so many arrangements touching our scientific institutions give rise to a hopeless feeling among those who are familiar with both the history and the facts connected with them.

## *NOTES.*

M. PRILLIEUX has been elected a member of the Paris Academy of Sciences, in succession to the late M. Naudin.

WE regret to see the announcement of the death of Sir Frederick McCoy, K.C.M.G., F.R.S., Professor of Natural Sciences in the University, Melbourne.

MR. W. H. PREECE, C.B., F.R.S., has accepted the presidency of the eighteenth Congress of the Sanitary Institute to be held in Southampton from August 29 to September 2.

THE foundation stone of a museum of Oceanography was laid at Monaco on April 25. The museum will contain the collections made by the Prince of Monaco during the expeditions of the yacht *Princess Alice*. It will contain not only exhibition rooms, but also laboratories for the use of men of science who wish to work upon the collections.

DR. J. BUCKLEY BRADBURY, Downing Professor of Medicine in the University of Cambridge, will deliver the Croonian lectures of the Royal College of Physicians of England in June, on "Some Points in Connection with Sleep, Sleeplessness, and Hypnotics."

WE learn from the *Botanical Gazette* that the Museum and laboratory building in the New York Botanical Garden is making fair progress towards completion. It is now entirely enclosed, and the partition walls and other rough interior work are nearly finished. It will probably be ready for occupancy late in the spring.

THE Department of Science and Art has received through the Foreign Office an intimation that the Ghent Horticultural Congress has been postponed from June 3 to July 8.

THE projected expedition of the Duke of the Abruzzi, nephew of King Humbert, to the North Pole is exciting great interest in Italy. A Reuter telegram from Rome states that the Duke, who will be accompanied by three officers of the navy, two sailors, four mountain guides, ten Norwegian sailors, and an Eskimo, will embark about the middle of June at Laurvig, Norway, whence he will proceed to Franz Josef Land, trying to attain as northerly a point as possible. The party will winter in the most northerly port attainable, and will spend enforced leisure in making scientific observations and preparing revictualling stations. In the spring the Duke and his companions will proceed towards the North Pole on sledges drawn by dogs, 120 of which he will embark at Archangel, or, if necessary, in a balloon. The expedition takes two balloons. If all goes well, the Prince will be away some eighteen months. The ship in which the Duke of the Abruzzi will sail is called the *Stella Polare*.

THE Rev. T. Neville Hutchinson, whose death occurred on May 6, did much to advance the interests of science by his work some years ago as senior science master at Rugby. Forty years ago Rugby was the only public school in which science was taught at all. Harrow and Eton followed, though not with the same liberality as Rugby, where a few years later a special suite of lecture-rooms and laboratories was devoted to science. It was Mr. Hutchinson who reorganised the science work at Rugby in 1870, and in the first volume of NATURE he described the new laboratories and other buildings erected there for purposes of scientific instruction. Mr. Hutchinson was born in 1826. He was second master at King Edward's School, Birmingham, in 1860–65, and science master at Rugby from 1865 to 1883, when he became vicar of Broadchalke, Wilts. He resigned his vicarage last October, and was made Canon of Salisbury. He was a gifted teacher and lecturer, and old Rugbeians will sincerely regret to learn of his death.

THE death, shortly before completing his sixtieth year, of Mr. Philip Thomas Main, of St. John's College, Cambridge, is announced in the *Athenaeum*. Mr. P. T. Main published "An Introduction to Plane Astronomy" for University use in 1865, and also assisted his father, the Rev. Robert Main, who was for twenty-five years Chief Assistant at the Royal Observatory, Greenwich, and afterwards for eighteen years Radcliffe Observer at Oxford, in his large work on "Practical and Spherical Astronomy," which appeared in 1863. Subsequently he turned his chief attention to chemistry, and for many years held the post of superintendent of the laboratory at St. John's College.

THE Council of the British Medical Association desire to remind members of the profession engaged in researches for the advancement of medicine and the allied sciences that they are prepared to receive applications for grants in aid of such research. Applications for sums to be granted at the next annual meeting must include details of the precise character and objects of the research which is proposed, and must be made on or before June 15 in writing addressed to the General Secretary of the Association. The Council are prepared to receive applications for one of the three research scholarships which is vacant, of the value of 150*l.* per annum, tenable for one year, and subject to renewal by the Council for another year. Applications may also be sent in for a scholarship of 200*l.*, for the study of some subject in the department of State Medicine, in memory of the late Mr. Ernest Hart.

THE thirtieth general meeting of the Institution of Mining Engineers will be held in London on May 25. Among the papers to be read, or taken as read, are the following:—Presidential address, by Mr. J. A. Longden; alternating currents and their possible applications to mining, Part i., by Mr. Sydney F. Walker; metric weights and measures, by Mr. J. Emerson Dowson; Petroleum in Burma, by Dr. Fritz Noetling; mineral resources of Vancouver and adjacent islands, British Columbia, by Mr. Wm. M. Brewer; and a new process of seasoning and preserving timber and other fibrous substances by means of electricity, by Mr. H. Baillie-Weaver.

ARRANGEMENTS are being made for a visit of the Institution of Electrical Engineers to Switzerland in September next. As at present arranged, members will visit the Rheinfelden works on Saturday, September 2, will proceed on the same day to Zürich, and will remain there until September 6. During this time visits will be paid to various industrial works, and to certain power stations and tramway and lighting installations in the district, including, it is hoped, a visit to the Schaffhausen works. The members will then proceed to Lucerne, and, after inspecting the street railways of that town and, if time permit, the Rathhausen works and the Stansstad-Engelberg Railway, will travel, *via* the Brünig Pass, to Interlaken. Here opportunity will be given for visiting both the Jungfrau Railway (*via* the Wengern Alp route) and the Burgdorf-Thun Railway, as well as other places of electrical interest in the neighbourhood; and the visit will end on Saturday, September 9. The annual

conversazione of the Institution will be held at the Natural History Museum, South Kensington, on Thursday, June 15.

A DISASTROUS explosion occurred on Friday at the Kurtz's Chemical Works, belonging to the United Alkali Company, St. Helens, Lancashire. The force of the explosion was so great that it was felt not only at Prescot and Haydock, about four miles away, but also in the suburbs of Liverpool and at Leigh, which is twelve miles distant. Mr. Stewart, managing director of the United Alkali Company, says that about 10 a.m. he saw that the side of the chlorate of potassium crystallising vessel was on fire. These vessels are of wood, but lined with lead, and there were many of them in the crystallising house. The officials were promptly warned, and they brought up the fire extinguishing appliances; but in ten minutes the fire had reached the store containing a considerable quantity of chlorate. The men were instantly sent from the works. When the flames reached the chlorate store a violent explosion resulted, and the refining and the grinding plant was completely destroyed. This was followed by another explosion, which reduced the chemical works to ruins.

FROM the ninth report of the British Association Committee on photographs of geological interest, we learn that the total number of photographs now in the collection is two thousand and one. Amongst the more noteworthy additions referred to in the report may be mentioned an interesting set from Arran, Cumbrae, Ailsa Craig, and the Fifeshire volcanic necks, together with some from Westmoreland and Banffshire; a set from Glenroy and the Scottish Highlands; large series from Westmoreland and Yorkshire, many of them representing glacial phenomena, unconformities, and faults; pleistocene deposits; dykes in the new red sandstone; silurian, cambrian, and igneous rocks of the Midlands; raised beaches in Devon ridge; oolites; a set from the Rochdale district; a set from the Isle of Man; and one of typical specimens of rocks and microscopic slides. The Committee call attention to the small amount of work yet done in such districts as N. and S. Wales, the Yorkshire Dales and Moors, the Malverns, the districts round Oxford and Cambridge, Cornwall, the Southern Uplands, the Central Valley of Scotland, and Central and Southern Ireland.

THE *Société Internationale des Électriciens* have just published an account of a tour, made by *L'École supérieure d'Électricité*, to investigate the power-transmission systems at certain stations in Switzerland. In this tour, of only one week, the students collected a very useful amount of information with regard to the hydraulic machinery and electrical plant. They had special facilities for examining the systems, and in many cases they obtained drawings of details of construction. These drawings now form part of the account of their excursion. We notice with particular interest the description of various methods for regulating turbines and electro-motors. After the various hydraulic installations, the methods of distribution are considered. A chapter on electric traction follows, and then an account of the works of Brown-Boveri and the Oelikon factory. Lastly, there is a note on the manufacture of calcium carbide. Similar tours might with advantage be arranged by English technical schools. In their devotion to "*la belle science*" the railway companies allowed a reduction of fifty per cent. on all fares. Similar reductions might be allowed by British railway companies.

THE *Transactions* of the Swedish Academy of Science, No. 7, 1898, contains a paper, in English, by Mr. John Rhodin, on the theory of storage cells, dealing especially with the phenomena attending the cessation of current as depending upon the concentration of the electrolyte and the amount of active material.

MR. J. ELSTER and Mr. H. Geitel have contributed a joint paper to *Terrestrial Magnetism* of March last, relating to a continuation of their important researches on the electricity of rainfall, perhaps the most difficult of all electrical phenomena; the subject is, in fact, so complicated as to allow but little prospect of establishing fixed rules of the processes concerned. Their previous investigations referred more particularly to the determination of the sign of the potential, while the present paper deals with the measurement of the amount. To carry this out satisfactorily an apparatus is required which will show, in rapid succession, both high differences of potential of several thousand volts as well as small differences of, say, 100 volts, while the capacity of the apparatus must be so small as to exhibit rapid variations of the field from positive to negative extremes. The apparatus devised for the purpose is illustrated and minutely described, and the results obtained, while confirming their previous determinations of the sign of the electricity during atmospheric precipitation, show that this may bring with it very considerable amounts of both positive and negative electricity.

THE Deutsche Seewarte has published the eighth volume of its valuable meteorological observations made at foreign stations. It includes some places in Labrador, from which observations have been regularly published since 1883; these are specially important, because many barometric minima travel across Labrador from Canada to the Atlantic Ocean. We are glad to see that the Seewarte intends to increase the number of foreign stations, by including others which do not belong properly to German Protectorates or Colonies. The present volume contains observations from Mogador, Campinas (Brazil), and Fray Bentos (Uruguay). The observations are in all cases carefully made by German officials, or residents, and in nearly all instances the instruments have been supplied by, or through, the Seewarte, and are therefore thoroughly trustworthy.

A REPORT by Prof. David Hansemann, of Berlin, on the brain of Hermann von Helmholtz, is referred to in the *British Medical Journal*. The great physicist died of apoplexy on September 8, 1894, at the age of seventy-three. The circumference of the head was 59 centimetres, that of the skull 55 centimetres. The breadth of the skull was 15·5, and its length 18·3 centimetres. The cephalic index was therefore 85·25, showing a broad head. Helmholtz's head was about equal in size to that of Bismarck, and rather smaller than that of Wagner, both of whom had big heads. On the other hand, Darwin's head was only 56·3 centimetres in circumference. The weight of the brain, with its blood, was 1700 grams, without the blood 1440 grams, being about 100 grams heavier than the average human brain. The sulci were very deep and well marked, especially in those parts of the brain which Flechsig has shown to be concerned in associations. The frontal convolutions in particular were deeply cut by very numerous sulci. Helmholtz, like Cuvier, was somewhat hydrocephalic in youth. It has been maintained by Perls, and also by Edinger, that hydrocephalus in early life may be an advantage, inasmuch as it enlarges the skull and gives the brain space for growth. Prof. Hansemann appears to be of the same opinion.

A MEMOIR on the geology of the country around Carlisle, by Mr. T. V. Holmes, has just been issued by the Geological Survey. The country described is almost wholly covered with superficial deposits, boulder clay and gravel, peat, alluvium and blown sand. As it has been customary to issue two editions of the Geological Survey map, one with, and the other without drift, it may be inferred that considerable difficulty was felt in interpreting the "solid" geology of this region. The concealed rocks consist largely of the New Red Series, St. Bees sandstone, gypseous shales, Kirklinton sandstone, and Stanwix shales—with an outlier of Lower Lias, but no evidence of the

Rhætic beds. The precise underground extent and the relations of the subdivisions of the New Red Series have been the subject of considerable difference of opinion, but the evidence obtained from borings and river-cliffs is clearly stated by Mr. Holmes.

MR. WILLIAM H. DALL makes some remarks (*Proc. Acad. Nat. Sc. Philad.*, January 1899) on the celebrated Calaveras skull, which was found more than thirty years ago in a bed of gravel 132 feet below the surface of the uppermost lava-bed of Bald Hill, one of the "table mountains" of Calaveras County, California. Mr. Dall was in California at the time of the discovery, and records his evidence in favour of its genuineness.

ONE of the best-known examples of change of level during earthquakes is that of the great Kutch earthquake of 1819, when a large portion of the Rann of Kutch was depressed and immediately flooded by the sea, while at the same time a long mound was seen, which is known as the Allah Bund or Dam of God. With regard to the depression there can be no doubt; but the character of the elevation, whether real or only apparent, is not so certain. The former view, supported by Lyell, was held until 1872, when Mr. A. B. Wynne (followed by Prof. Suess) argued that the Allah Bund represented merely the comparatively steep slope connecting the area which had been depressed from that whose level was unchanged. In a paper in the *Memoirs* of the Geological Survey of India (vol. xxviii., pt. i., 1898), Mr. R. D. Oldham favours the older view, and presents a map and section (made by Captain Baker in 1844), which show that there was an actual upward slope of the ground from the plain on the north to the southern scarp of the Allah Bund.

EFFORTS to determine the molecular structure of certain crystals have been made by means of etching them with hydrofluoric acid or other reagents. The importance to petrographers of etch-figures in the investigations of amphiboles (hornblende, &c.) forms the subject of an elaborate paper by Mr. R. A. Daly (*Proc. Amer. Acad. Arts and Sciences*, March 1899).

THE New South Wales Department of Public Health has just issued a report, by Mr. Frank Tidswell, principal assistant medical officer of the Government, on protective inoculation against tick-fever. The colony, in view of the ravages wrought by this disease in Queensland, are making strenuous efforts to prevent a repetition of the disaster in New South Wales. The subject has been very carefully investigated by American authorities, and the results obtained by Mr. Tidswell confirm those previously obtained in America. It appears that more or less efficient protection from the disease can be procured by inoculating the blood of animals which have recovered from the fever, whereby the disease is produced in a mild form. Such artificial production of the disease is sometimes attended with considerable risk to the animal treated. Experience has shown, however, that it is principally older cattle which succumb, although, curiously, bulls, whether young or old, are extremely susceptible to tick-fever, and the greatest care has to be exercised in carrying out the inoculations. The period over which immunity lasts has not, so far, been accurately determined, but immunity is acquired as early as six days after the subsidence of the fever. The disease appears to be widely distributed, having been identified in America, Jamaica, the Argentine Republic, South Africa, Roumania, and Java. It was first described by American investigators in 1893, and was called Texas or Southern cattle fever, in consequence of the locality where it was originally discovered. In Australia it is usually known as tick-fever, owing to the part played by ticks in transmitting what is now known to be the real cause of the disease, the micro-organism called by its discoverers *Pyrosoma bigeminum*. At present the protective inoculation system is in a very elementary stage, but it is confidently anticipated that with improved methods, based upon further researches, a very valuable measure will be introduced for effectually compassing this ruinous pest.

THE *National Geographic Magazine* for April contains an account, by Mr. Walter D. Wilcox, of two expeditions to the headquarters of the Saskatchewan. The two main branches of the river start from the same ice-fields in the high Rockies, and after diverging several hundred miles unite in the plains 900 miles from the source. Mr. Wilcox reached the region of the sources by ascending the Bow River from Laggan, and amongst other geographical results of interest discovered a pass from the Saskatchewan to the Athabasca.

A NOTE on a harpoon-head found in a whale in the Bering Sea in August 1890, is contributed to the *National Geographic Magazine* by Mr. W. H. Dall. Marks on the iron showed that it belonged to the American whaler *Montezuma*, which was engaged in the North Pacific about the years 1850–54; the whale must, therefore, have carried it for between thirty-six and forty years. Mr. Dall also gives some observations by Captain E. P. Herendeen with regard to whales supposed from similar evidence to have made the north-east or north-west passage.

THE *Comptes rendus* of the Paris Geographical Society (1899, No. 2) contain a note by M. Jules Richard on a series of nine short land excursions made from the Prince of Monaco's yacht *Princess Alice*, during her Arctic cruise in the summer of 1898. A number of observations, chiefly zoological, were made from various points and islands in the neighbourhood of Spitsbergen. Photographs taken at Bear Island, Hope Island, and Sassen Bay are reproduced.

DR. HAGBART MAGNUS, of Bergen, contributes an important paper on the population of Norway to the *Zeitschrift der Gesellschaft fur Erdkunde*, a summary of a larger memoir already published in the Norwegian language. The distribution of centres of population is discussed with reference to the geography of different parts of the country, the inhabited districts being separated into coast regions, fjord regions, and valley regions. The transition from each of these into the uninhabited regions is carefully examined, and the development of unfavourable conditions of various kinds traced. A sketch-map, preliminary to an attempt to construct a map showing the density of population in southern Norway, is appended.

IN an article in the *Botanical Gazette* for April, Prof. W. F. Ganong describes the following appliances for the elementary study of vegetable physiology in use at Smith College, Northampton, Mass.:—A temperature stage, a clinostat, a recording auxanometer, an osmometer, a respiration apparatus, a germination box, a root-pressure gauge.

THE annual report of the Royal Botanic Gardens, Trinidad, for the year 1898 affords evidence of steady work done by the superintendent, Mr. J. H. Hart, and his staff, in the cultivation of economic plants, in the herbarium, and in exchanges with other parts of the world. A newly introduced species of cacao, *Theobroma pentagona*, may possibly be of commercial importance.

IN a paper in the *Biologisches Centralblatt*, Dr. L. Jost argues, from the remarkable tendency in *Linaria spuria* towards the sudden production of anomalies in the flower, which might be regarded as establishing new species, or even new genera, that the differentiation of species and genera may have been a much more rapid process than has generally been assumed by evolutionary naturalists.

WE have received two interesting reprints from the *Memoirs* of the Boston Society of Natural History for 1899:—Localised Stages in Development in Plants and Animals, by Mr. R. T.

Jackson; and the Development, Structure, and Affinities of the Genus *Equisetum*, by Mr. E. C. Jeffrey. The former paper is occupied by illustrations of the law laid down by the author, that throughout the life of an individual stages may be found in localised parts which are similar to stages found in the young, and the equivalents of which are to be sought in the adults of ancestral groups. The investigations of Mr. Jeffrey lead him to the conclusion that the Equisetales are nearly allied to the Lycopodiales, and that they are descended from the Sphenophyllales, with which they agree closely in all important particulars except the structure of the stele.

MR. MURRAY has in preparation, and will publish as soon as possible, Sir William Crookes' reply to the many criticisms evoked by his address to the British Association last year.

THE monthly meeting of the Edinburgh Mathematical Society was held on Friday, May 12, when "The Treatment of Proportion in Elementary Mathematics" was discussed. Dr. Morgan, President, occupied the chair.

THE 143rd meeting of the Yorkshire Naturalists' Union will be held at Dent, on Whit-Monday, May 22, for the investigation of the valley of the Dee, the northern slopes of Whernside, Gragreth, Holme Fell, and the neighbourhood.

MESSRS. MARION AND CO. have just introduced a new hand camera—the Cut-film Swallow Camera—which has several commendable points. The camera takes thirty flat films, without notches, the size being the $\frac{1}{4}$-plate-$4\frac{1}{4} \times 3\frac{1}{4}$. Its weight loaded with thirty films is only 4 lbs. The lens is a single achromatic lens of the fixed focus type and good covering power.

A NEW section of the second edition of Prof. Ostwald's "Lehrbuch der allgemeinen Chemie" has been published by Mr. Wilhelm Engelmann, Leipzig. The pages included in this Lieferung extend from 605 to 828, dealing with chemical equivalents of the second order. Another section on the same subject will bring the second part of the second volume to an end. The third part of the second volume, which will conclude the work, will be concerned chiefly with special chemical dynamics. A supplement will be published dealing with advances made while the work has been passing through the press.

PROF. GATTERMANN, of Heidelberg, has added another to the list of silicon acids. The new compound, which he terms silicomesoxalic acid, is obtained by leaving the chloride $Si_3Cl_8$ in a platinum dish exposed to the air. Hydrochloric acid is evolved and the octochloride is slowly transformed into a white amorphous mass of silicomesoxalic acid to which the formula $HO.OSi - Si(OH)_2 - SiO.OH$ is ascribed. It is very unstable, and on heating decomposes with a flash. When quite pure and dry, a touch is sufficient to effect this change.

THE additions to the Zoological Society's Gardens during the past week include a Ring-tailed Lemur (*Lemur catta*, ♀) from Madagascar, presented by Mrs. Penn Curzon; a Common Badger (*Meles taxus*, ♀), British, presented by Mr. John N. Docwra; an Angolan Vulture (*Gypohierax angolensis*) from North-west Africa, presented by Staff-Sergeant Patten; a Hoary Snake (*Pseudaspis cana*), a Rough-keeled Snake (*Dasypeltis scabra*), two Rhomb-marked Snakes (*Trimenorhinus rhombeatus*), two Crossed Snakes (*Psammophis crucifer*) from South Africa, presented by Mr. J. E. Matcham; a Common Snake (*Tropidonotus natrix*), British, presented by Mr. E. C. Brook; two Common Marmosets (*Hapale jacchus*) from South-east Brazil, a Reticulated Python (*Python reticulatus*) from the East Indies, a Spiny-tailed Iguana (*Ctenosaura acanthura*) from Central America, a South Albemarle Tortoise (*Testudo vicina*) from the Galapagos Islands, deposited; two Crowned Lemurs (*Lemur coronatus*), born in the Gardens.

## OUR ASTRONOMICAL COLUMN.

PARTIAL ECLIPSE OF THE SUN, JUNE 7.—This eclipse will be visible at Greenwich and throughout Northern Europe and Northern Asia. The Greatest Eclipse will be visible in latitude 67° 18′ N., and longitude 99° 5′ W. of Greenwich, on June 7d. 18h. 34·0m.; the magnitude being 0·611 (sun's diameter = 1). The following table gives the details for British stations, Greenwich mean time being used in all cases except that of Dublin, where local mean time is taken.

| Station | Begins | Greatest Eclipse | Ends | Magnitude |
|---|---|---|---|---|
| | h. m. | h. m. | h. m. | |
| Greenwich ... ... | 16 42·8 | 17 17·4 | 17 53·4 | 0·188 |
| Cambridge ... ... | 16 43·2 | 17 18·6 | 17 55·5 | 0·197 |
| Oxford... ... ... | 16 42·8 | 17 18·2 | 17 55·1 | 0·200 |
| Liverpool ... ... | 16 43·8 | 17 21·5 | 18 0·9 | 0·233 |
| Edinburgh ... ... | 16 45·7 | 17 25·9 | 18 7·8 | 0·263 |
| Dublin... ... ... | 16 18·6 | 16 57·3 | 17 37·6 | 0·253 |

At Greenwich and approximately throughout the British Isles the contacts are as follows:—

| | | | | |
|---|---|---|---|---|
| Angle from North Point | First contact | 42° | towards the West | For *direct* image. |
| | Last ,, | 29° | ,, ,, East | |
| Angle from Vertex | First ,, | 6° | ,, ,, West | |
| | Last ,, | 70° | ,, ,, East | |

COMET 1898 *a* (SWIFT).—The following ephemeris is by Herr H. Kreutz, in *Astr. Nach.*, No. 3556:—

*Ephemeris for 12h. Berlin Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ | Br. |
|---|---|---|---|
| May 18 | ... 22 34 21 | ... +43 42·9 | |
| 19 | ... 23 37 | ... 45 23·1 | ... 1·77 |
| 20 | ... 22 11 40 | ... 47 4·2 | |
| 21 | ... 21 58 20 | ... 48 44·5 | ... 1·79 |
| 22 | ... 43 29 | ... 50 22·7 | |
| 23 | ... 26 59 | ... 51 56·5 | ... 1·79 |
| 24 | ... 21 8 40 | ... 53 23·9 | |
| 25 | ... 20 48 31 | ... +54 41·8 | ... 1·77 |

During the week the comet passes through Lacerta without being near any conspicuous stars. On the 21st it enters Cygnus, being about 10° north-east of *α* Cygni on the 24th.

TEMPEL'S COMET (1873 II.).—M. L. Schulhof gives the following ephemeris for this comet in *Astr. Nach.*, No. 3554):—

*Ephemeris for 12h. Paris Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ ″ | Br. |
|---|---|---|---|
| May 18 | ... 19 12 16·1 ... | − 3 55 17 | |
| 19 | ... 13 53·1 ... | 3 53 15 | |
| 20 | ... 15 29·7 ... | 3 51 28 | ... 0·764 |
| 21 | ... 17 6·0 ... | 3 49 55 | |
| 22 | ... 18 41·8 ... | 3 48 38 | |
| 23 | ... 20 17·3 ... | 3 47 37 | |
| 24 | ... 21 52·3 ... | 3 46 53 | ... 0·869 |
| 25 | ... 19 23 27·0 ... | − 3 46 27 | |

The comet is moving slowly in a north-easterly direction through the constellation Aquila.

RETURN OF HOLMES' COMET (1892, III.).—The following ephemeris is by Mr. H. J. Zwiers in *Astr. Nach.*, No. 3553.

*Ephemeris for 12h. Greenwich Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ ″ | Br. |
|---|---|---|---|
| May 18 | ... 0 34 53·2 | ... + 10 12 50 | ... 0·0298 |
| 20 | ... 38 22·5 | ... 10 50 0 | ... ·0301 |
| 22 | ... 41 51·1 | ... 11 27 8 | ... ·0304 |
| 24 | ... 45 19·1 | ... 12 4 13 | ... ·0306 |
| 26 | ... 48 46·2 | ... 12 41 15 | ... ·0309 |
| 28 | ... 52 13·1 | ... 13 18 14 | ... ·0312 |
| 30 | ... 55 39·1 | ... 13 55 8 | ... ·0315 |
| June 1 | ... 0 59 4·4 | ... + 14 31 58 | ... ·0318 |

No information as to any observations of this comet has yet been received. The positions given above would indicate it to be moving to the north-east through Pisces; at the end of the month it will be about half-way between *γ* Pegasi and *β* Arietis, but after this it will probably be lost owing to its nearing the sun.

ROTATION PERIOD OF MARS.—Mr. W. F. Denning has recently secured some measures of the times of transit of the Syrtis Major (Kayser Sea), which in conjunction with observations made by him in 1884 and 1869 give a critical value for the period (*Observatory*, May 1899, p. 195). On February 4, 1869, the Syrtis Major was in mid-transit at 11h., while on February 14, 1884, when Mars was similarly situated with reference to the Earth, the transit occurred at 5h. 55m. Other transits were taken as February 15, 6h. 35m.; February 19, 9h. 5m.; February 22, 11h. 4m. Now, after another interval of fifteen years, the transit on March 7, 1899, occurred at 8h. 31m. The whole period between 1869 February 4, 11h. and 1899 March 7, 8h. 31m., comprises 10,987 days, 21 hours, 31 minutes, during which Mars has performed 10,710 rotations. The mean period during this interval thus becomes

24h. 37m. 22·70s.

This value is intermediate between those of Proctor and Bakhuyzen.

## *AN IMPROVED RESISTANCE-BOX.*

MESSRS. GAMBRELL BROS. have recently introduced a resistance-box of improved design, which gives promise of eliminating several of the disadvantages of the usual post-office pattern. Fig. 1 shows the appearance of the box with the cover removed to show the working parts. The coils, which hang vertically in the lower part of the box, are brought up to

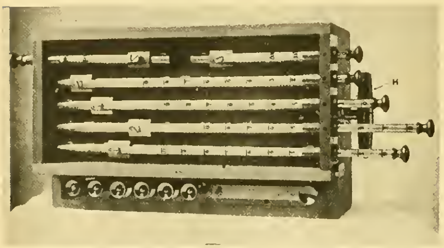


FIG. 1.—General view of the box, from above, showing the numbered slide rods, the contact shoes and the terminal studs of the coils. The handle (H) at the right is for clamping all the contact shoes simultaneously.

terminal studs (T) seen in Fig. 2, arranged in five rows, one of which, in two sections, forms the "ratios" used as two arms of the bridge. The upper surfaces of these studs are semicircular, fitting the concave surfaces of the sliding contact shoes (S). The four rows other than the "ratios" provided for thousands, hundreds, tens and units, reckoned from the side nearest the terminals and key. Each of these contact shoes slides with slight friction on a brass bar running the length of the box, and supported at each end by metal pillars held down by springs inside the box. To move the shoes from one stud to another other

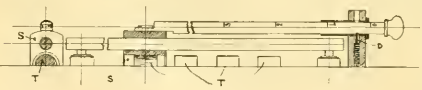


FIG. 2.—Showing construction of slider, spring contact bar, &c.

brass rods are attached, which slide through ebonite bushes on the end of the box. On these rods are engraved the figures giving the amount of resistance in use, the value of any particular resistance in circuit being indicated by the number showing just outside the ebonite bush. To ensure the contact shoe being properly fixed on the studs, a spring detent (D, Fig. 2) is provided under each bar, so that the resistances may be changed without the experimenter needing to watch the bar. All the bars being arranged to give the resistance required, it will be evident that its total amount can be read straight off at the end of the box, being given by the row of figures close to the four ebonite bushes. For example, the reading of the resistance in circuit, as shown in Fig. 1, is 2310. This is itself a great convenience, and will prevent any chance error in adding. As an additional help to maintaining the contacts as constant and perfect as possible, when the proper resistance has been found, all the four shoes are drawn tightly down on to the terminal studs by turning the handle H, seen under the ends of the rods in Fig. 1. This actuates a cam inside, which moves the small pillars at each end of the brass bars passing through the contact shoes. At the same time, the arrangement acts as a clamp, so that while the handle is turned the resistances cannot be changed. All the pillars are held down by springs, so that when not clamped by the handle H the sliding to and fro is accompanied by sufficient friction to keep the contact surfaces clean.

In consequence of the ingenious method adopted for reading off the figures, rendering access to the contacts themselves quite unnecessary, the whole of the system of studs and sliding bars is covered in permanently, so that they and the ebonite insulating block are kept free from dust and corrosion. The studs, being a considerable distance apart, should permit of a very high insulation resistance, while at the same time allowing a large surface contact between the shoe and the stud.

It will be seen that this new form of box has many advantages to recommend it to notice. The simplicity and rapidity of reading, its compactness, and its non-liability to deterioration, should cause it to find favour both in laboratory and testing-room experience.

## *TRANSPARENCY AND OPACITY.*[1]

ONE kind of opacity is due to absorption; but the lecture dealt rather with that deficiency of transparency which depends upon irregular reflections and refractions. One of the best examples is that met with in Christiansen's experiment. Powdered glass, all from one piece and free from dirt, is placed in a bottle with parallel flat sides. In this state it is quite opaque; but if the interstices between the fragments are filled up with a liquid mixture of bisulphide of carbon and benzole, carefully adjusted so as to be of equal refractivity with the glass, the mass becomes optically homogeneous, and therefore transparent. In consequence, however, of the different dispersive powers of the two substances, the adjustment is good for one part only of the spectrum, other parts being scattered in transmission much as if no liquid were employed, though, of course, in a less degree. The consequence is that a small source of light, backed preferably by a dark ground, is seen in its natural outlines but strongly coloured. The colour depends upon the precise composition of the liquid, and further varies with the temperature, a few degrees of warmth sufficing to cause a transition from red through yellow to green.

The lecturer had long been aware that the light regularly transmitted through a stratum from 15 to 20 mm. thick was of a high degree of purity, but it was only recently that he found to his astonishment, as the result of a more particular observation, that the range of refrangibility included was but two and a half times that embraced by the two D-lines. The poverty of general effect, when the darkness of the background is not attended to, was thus explained, for the highly monochromatic and accordingly attenuated light from the special source is then overlaid by diffused light of other colours.

More precise determinations of the range of light transmitted were subsequently effected with thinner strata of glass powder contained in cells formed of parallel glass. The cell may be placed between the prisms of the spectroscope and the object-glass of the collimator. With the above-mentioned liquids a stratum 5 mm. thick transmitted, without appreciable disturbance, a range of the spectrum measured by 11·3 times the interval of the D's. In another cell of the same thickness an effort was made to reduce the difference of dispersive powers. To this end the powder was of plate glass and the liquid oil of cedar-wood adjusted with a little bisulphide of carbon. The general transparency of this cell was the highest yet observed. When it was tested upon the spectrum, the range of refrangibility transmitted was estimated at thirty-four times the interval of the D's.

As regards the substitution of other transparent solid material

[1] A discourse delivered at the Royal Institution on Friday, March 24, by the Right Hon. Lord Rayleigh, F.R.S.

for glass, the choice is restricted by the presumed necessity of avoiding appreciable double refraction. Common salt is singly refracting, but attempts to use it were not successful. Opaque patches always interfered. With the idea that these might be due to included mother liquor, the salt was heated to incipient redness, but with little advantage. Transparent rock-salt artificially broken may, however, be used with good effect, but there is some difficulty in preventing the approximately rectangular fragments from arranging themselves too closely.

The principle of evanescent refraction may also be applied to the spectroscope. Some twenty years ago an instrument had been constructed upon this plan. Twelve 90° prisms of Chance's "dense flint" were cemented in a row upon a strip of glass (Fig. 1), and the whole was immersed in a liquid mixture of bisulphide of carbon with a little benzole. The dispersive power of the liquid exceeds that of the solid, and the difference amounts to about three-quarters of the dispersive power of Chance's "extra dense flint." The resolving power of the latter glass is measured by the number of centimetres of available thickness, if we take the power required to resolve the D-lines as unity. The compound spectroscope had an available thickness of 12 inches or 30 cm., so that its theoretical resolving power (in the yellow region of the spectrum) would be about 22. With the aid of a reflector the prism could be used twice over, and then the resolving power is doubled.

One of the objections to a spectroscope depending upon bisulphide of carbon is the sensitiveness to temperature. In the ordinary arrangement of prisms the refracting edges are vertical. If, as often happens, the upper part of a fluid prism is warmer than the lower, the definition is ruined, one degree (Centigrade) of temperature making nine times as great a difference of refraction as a passage from $D_1$ to $D_2$. The objection is to a great extent obviated by so mounting the compound prism that the refracting edges are *horizontal*, which of course entails a horizontal slit. The disturbance due to a stratified temperature is then largely compensated by a change of focus.

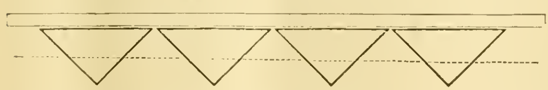

FIG. 1.

In the instrument above described the dispersive power is great—the D-lines are seen widely separated with the naked eye—but the aperture is inconveniently small (½-inch). In the new instrument exhibited, the prisms (supplied by Messrs. Watson) are larger, so that a line of ten prisms occupies 20 inches. Thus, while the resolving power is much greater, the dispersion is less than before.

In the course of the lecture the instrument was applied to show the duplicity of the reversed soda lines. The interval on the screen between the centres of the dark lines was about half an inch.

It is instructive to compare the action of the glass powder with that of the spectroscope. In the latter the disposition of the prisms is regular, and in passing from one edge of the beam to the other there is complete substitution of liquid for glass over the whole length. For one kind of light there is no relative retardation; and the resolving power depends upon the question of what change of wave-length is required in order that its relative retardation may be altered from zero to the quarter wave-length. All kinds of light for which the relative retardation is less than this remain mixed. In the case of the powder we have similar questions to consider. For one kind of light the medium is optically homogeneous, *i.e.* the retardation is the same along all rays. If we now suppose the quality of the light slightly varied, the retardation is no longer precisely the same along all rays; but if the variation from the mean falls short of the quarter wave-length it is without importance, and the medium still behaves practically as if it were homogeneous. The difference between the action of the powder and that of the regular prisms in the spectroscope depends upon this, that in the latter there is complete substitution of glass for liquid along the extreme rays, while in the former the paths of all the rays lie partly through glass and partly through liquid in nearly the same proportions. The difference of retardations along various rays is thus a question of a deviation from an average.

It is true that we may imagine a relative distribution of glass and liquid that would more nearly assimilate the two cases. If, for example, the glass consisted of equal spheres resting against one another in cubic order, some rays might pass entirely through glass and others entirely through liquid, and then the quarter wave-length of relative retardation would enter at the same total thickness in both cases. But such an arrangement would be highly unstable; and, if the spheres be packed in close order, the extreme relative retardation would be much less. The latter arrangement, for which exact results could readily be calculated, represents the glass powder more nearly than does the cubic order.

A simplified problem, in which the element of chance is retained, may be constructed by supposing the particles of glass replaced by thin parallel discs which are distributed entirely at random over a certain stratum. We may go further and imagine the discs limited to a particular plane. Each disc is supposed to exercise a minute retarding influence on the light which traverses it, and they are supposed to be so numerous that it is improbable that a ray can pass the plane without encountering a large number. A certain number ($m$) of encounters is more probable than any other, but if every ray encountered the same number of discs, the retardation would be uniform and lead to no disturbance.

It is a question of probabilities to determine the chance of a prescribed number of encounters, or of a prescribed deviation from the mean. In the notation of the integral calculus the chance of the deviation from $m$ lying between $\pm r$ is (see *Phil. Mag.*, 1899, vol. xlvii. p. 251)

$$\frac{2}{\sqrt{\pi}}\int_0^{\tau} e^{-\tau^2}\, d\tau,$$

where $\tau = r / \sqrt{(2m)}$. This is equal to ·84 when $\tau = 1·0$, or $r = \sqrt{(2m)}$; so that the chance is comparatively small of a deviation from $m$ exceeding $\pm \sqrt{(2m)}$.

To represent the glass powder occupying a stratum of 2 cm. thick, we may perhaps suppose that $m = 72$. There would thus be a moderate chance of a difference of retardations equal to, say, one-fifth of the extreme difference corresponding to a substitution of glass for liquid throughout the whole thickness. The range of wave-lengths in the light regularly transmitted by the powder would thus be about five times the range of wave-lengths still unseparated in a spectroscope of equal (2 cm.) thickness. Of course, no calculation of this kind can give more than a rough idea of the action of the powder, whose disposition, though partly a matter of chance, is also influenced by mechanical considerations; but it appears, at any rate, that the character of the light regularly transmitted by the powder is such as may reasonably be explained.

As regards the size of the grains of glass, it will be seen that as great or a greater degree of purity may be obtained in a given thickness from coarse grains as from fine ones, but the light not regularly transmitted is dispersed through smaller angles. Here again the comparison with the regularly disposed prisms of an actual spectroscope is useful.

At the close of the lecture the failure of transparency which arises from the presence of particles small compared to the wave-length of light was discussed. The tints of the setting sun were illustrated by passing the light from the electric lamp through a liquid in which a precipitate of sulphur was slowly forming (*op. cit.*, 1881, vol. xii. p. 96). The lecturer gave reasons for his opinion that the blue of the sky is not wholly, or even principally, due to particles of foreign matter. The molecules of air themselves are competent to disperse a light not greatly inferior in brightness to that which we receive from the sky.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The honorary degree of M.A. was conferred in Convocation on Tuesday upon Mr. Roland Trimen, F.R.S.

Convocation has passed the decree accepting the offer of the Royal Geographical Society of 400*l.* for five years for the furtherance of geographical studies in Oxford, and providing an equal contribution from the funds of the University.

CAMBRIDGE.—The following is the speech delivered on May 11 by the Public Orator, Dr. Sandys, of St. John's

College, in presenting Prof. Kowalevsky, of St. Petersburg, for the honorary degree of Doctor in Science:—

Russorum ab imperio maximo legatus ad nos subito advectus est vir illustris, qui investigandi rationes novas inter primos secutus, animantium formas quasdam inferiores ex alia in aliam paullatim mutatas identidem indagavit; qui in confinio inter genera vertebris instructa et vertebris carentia iampridem moratus, Amphioxi speciem ambiguam primus explicavit; qui larvae denique Ascidianae cum vertebrato animalium genere affinitatem imprimis indicavit. Atqui, ne talium quidem virorum praeceptis attonitus, larvae illius degeneris propinquitatem reformidabit homo non terrestris tantum sed etiam caelestis originis conscius, qui angelis paullo minor, gloria et honore est coronatus, super oves et boves, super feras omnes, super volucres et pisces, super omnia quae maris per vias pererrant, a Deo constitutus.

Duco ad vos Zoologiae Professorem Petropolitanum, ALEXANDRUM KOWALEVSKY.

The General Board have issued a report recommending that the stipends of the Reader in Botany (Mr. F. Darwin), the Lecturer in Organic Chemistry (Mr. Ruhemann), the Lecturer in Experimental Psychology (Dr. Rivers), and the Curator in Zoology (Mr. D. Sharp), should be increased; and that new Lectureships in Palæozoology and in Physical Anthropology should be established.

A University Lectureship in Applied Mathematics will be vacant at Michaelmas by the resignation of Mr. Love, now Sedleian Professor at Oxford. Candidates are to send their names to the Vice-Chancellor by May 30. The stipend is 50*l.* a year.

The new Professorship of Agriculture, with a stipend of 800*l.* a year contributed by the Drapers' Company, was established by grace of the Senate on May 11.

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THE Board of Education Bill was read for a third time, and passed, in the House of Lords on Monday.

THE foundation-stone of a new school and technical institute, connected with the Sir John Cass Foundation, in Jewry Street, Aldgate, was laid on Thursday last by the Bishop of London. The plans of Mr. A. W. Cooksey have been accepted for the new buildings, which will be in English Renaissance style, and will cost 45,000*l.*

MR. ANDREW CARNEGIE has written to the Right Hon. Joseph Chamberlain with reference to the proposed establishment of a University at Birmingham, and the correspondence is published in the *Birmingham Daily Post*. Mr. Carnegie refers in the correspondence to the great advantage which the iron and steel industries of the United States have derived from the Cornell University, and goes on to remark that "if Birmingham were to take that University as its model, where the scientific has won first place in the number of students, and give degrees in science as in classics, I should be delighted to contribute the last 50,000*l.* of the sum you have set out to raise to establish the scientific department." In addition to this Mr. Chamberlain, writing to the Lord Mayor of Birmingham, announces that an anonymous friend who had previously promised 25,000*l.* has agreed to increase his offer to 37,500*l.* on condition that the full amount of 250,000*l.* required for the *minimum* endowment is obtained. There still remains 12,000*l.* to be raised before the quarter of a million required is reached.

AT the annual celebration of Presentation Day of London University, held on May 10, the Earl of Kimberley presided for the first time as Chancellor. Referring to the Act passed last year, the Chancellor remarked that under the provisions of that Act and under the statutes made, the examination part of the University, by which the University had hitherto been known and in which it had done most excellent work, would be duly preserved. What was to be added was very important indeed, and it would become, he hoped, a great teaching University. They were at last beginning to appreciate the great changes which had taken place in the world, and in the advancement of science especially. Those changes had required others in the framing of the highest education. Not that they should for one moment abandon the old system of laying a good broad foundation of education, but that they should add to it the greater cultivation of the sciences, of economic science, and of all those arts which had grown to be of such great importance to this country. What they wanted was to bring together, as far as possible, all those various agencies provided for higher education in the metropolis.

INQUIRIES as to the schools in which leading men in various professions were educated have been made by *The School World*, and the results for men of science are published in the current number. Of 250 representative men of science—mostly Fellows of the Royal Society—chosen for the present inquiry, one-fifth received their early education either in private schools or at home under tutors. The schools which claim the greatest number of old pupils in the selected list are Edinburgh High School, Edinburgh Academy, and Aberdeen Grammar School. The Scotch schools are followed, as regards the number of old pupils of distinguished eminence in science, by the City of London School and King's College School. Eton, Harrow, and Rugby succeed these, and are in turn followed by Liverpool College, Royal Institution School (Liverpool), and St. Paul's. The remarkable point brought out by this comparison is the small part the great public schools have taken in training the leaders in science of the present day. When the men who are now in the foremost rank among philosophers were receiving their early education science was almost, if not quite, omitted from the public school curriculum, with the result that comparatively few boys from such schools have become eminent in the scientific world. The neglect of science in comparison with other subjects is shown by the fact that Eton, Harrow, Rugby, Winchester, Westminster, and one or two other public schools, though comparatively poor in their scientific record, are shown by *The School World* to have furnished the greatest number of leading men in Parliament, the Church, and the Law, Eton leading the way as regards numbers in each of these classes.

THE proposal to utilise the buildings of the Imperial Institute for the purposes of the new London University was referred to in the report read at the annual meeting of the Fellows of the Institute on Monday. Lord James of Hereford, who has succeeded the late Lord Herschell as chairman of the governing body, in moving the adoption of the report remarked that a new lease of life had been brought within the purview of the Institute. Those responsible for its management had been approached by the Government, who had to find accommodation for the London University. In the Institute they possessed a very great area of accommodation not needed by them, which could be devoted with very little adaptation for the purposes of the University. In the first place, to bring a great seat of learning under the roof of the Institute seemed to the governing body to be in accordance with the objects for which the Institute came into existence. But it was only right that he should tell them that in affording this accommodation to the London University they were receiving from the Government a very substantial return. He was not in the position to enter into any details, because all the arrangements had not yet been completed, but he might say that the negotiations were proceeding, and that by the financial return for the provision of the necessary accommodation for the University the governors of the Institute would be relieved of many burdens. The real result would be that they would have all anxiety removed with regard to the future conduct of the Institute.

## SCIENTIFIC SERIALS.

*Meteorologische Zeitschrift*, February.—Results of the international balloon ascent, by Dr. H. Hergesell. This is the first of a proposed series of papers; the present one deals principally with the range of temperature, as shown by observations made in a captive balloon at Strassburg on June 7 and 8, 1898. The results prove that in strata of free air, whose height exceeds a few hundred metres, the temperature possesses an extremely small diurnal range. During the night it scarcely amounts to a few tenths of a degree; while in the daytime a variation of some three or four degrees Centigrade may occur, even at a height of 800 metres, when vertical air currents exist. In the absence of these, the range would, in all probability, sink to a very low value.—On the characteristics of mild winters, by Dr. G. Hellmann. The last two mild winters have induced the author to revise his previous researches upon this subject, and he gives particulars of the 51 mild winters experienced in Berlin during the last 180 years. The principal results arrived at are: that mild winters scarcely ever occur singly, but in groups of two or three; that they are usually of long duration, from November to February or March; severe and long, late winters (February and March) seldom occur after mild mid-

winters; in mild mid-winters the greatest variations of temperature usually occur in January. After a very mild winter, a warm summer is more probable than after a winter which is only moderately mild. Dr. Hellmann pleads for synoptic charts for the whole globe—at least for short intervals, if longer periods cannot be undertaken.

In the *Journal of Botany* for April and May, Mr. A. Lister describes and figures some new or interesting species of Mycetozoa; Mr. E. A. N. Arber discusses the relationship to one another of the various forms of indefinite inflorescence; Mr. A. Gepp records the detection in Britain of a genus of Saprolegneous fungi, *Apodachlya;* Mr. G. S. West continues his account of the alga flora of Cambridgeshire; Mr. F. S. Williams, his critical notes on species of *Cerastium;* and Mr. H. C. Hart, his account of a botanical excursion in Donegal.

## SOCIETIES AND ACADEMIES.

### LONDON.

**Royal Society**, March 16.—"Experiments in Micro-metallurgy:—Effects of Strain. Preliminary Notice." By Prof. Ewing, F.R.S., and Walter Rosenhain, 1851 Exhibition Research Scholar, Melbourne University.

Much information has been obtained regarding the structure of metals by the methods of microscopic examination initiated by Sorby and successfully pursued by Andrews, Arnold, Charpy, Martens, Osmond, Roberts-Austen, Stead, and others. When a highly polished surface of metal is lightly etched and examined under the microscope, it reveals a structure which shows that the metal is made up in general of irregularly shaped grains with well-defined bounding surfaces. The exposed face of each grain has been found to consist of a multitude of crystal facets with a definite orientation. Seen under oblique illumination, these facets exhibit themselves by reflecting the light in a uniform manner over each single grain, but in very various manners over different grains, and, by changing the angle of incidence of the light, one or another grain is made to flash out comparatively brightly over its whole exposed surface, while others become dark.

The grains appear to be produced by crystallisation proceeding, more or less simultaneously, from as many centres or nuclei as there are grains, and the irregular more or less polygonal boundaries which are seen on a polished and etched surface result from the meeting of these crystal growths. The grains are, in fact, crystals, except that each of their bounding surfaces is casually determined by the meeting of one growth with another.

The experiments, of which this is a preliminary account, have been directed to examine the behaviour of the crystalline grains when the metal is subjected to strain.

For this purpose we have watched a polished surface under the microscope while the metal was gradually extended until it broke. By arranging a small straining machine on the stage of the microscope, we have been able to keep under continuous observation a particular group of crystalline grains while the piece was being stretched, and have obtained series of photographs showing the same group at various stages in the process. Strips of annealed sheet iron, sheet copper, and other metals have been examined in this way. We have also observed the effects of strain on the polished surfaces of bars in a 50-ton testing machine by means of a microscope hung from the bar itself, and have further observed the effects of compression and of torsion.

When a piece of iron or other metal exhibiting the usual granular structure is stretched beyond its elastic limit, a remarkable change occurs in the appearance of the polished and etched surface, as seen by the usual method of "vertical" illumination. A number of sharp black lines appear on the faces of the crystalline grains: at first they appear on a few grains only, and as the straining is continued they appear on more and more grains On each grain they are more or less straight and parallel, but their directions are different on different grains. At first, just as the yield-point of the material is passed, the few lines which can be seen are for the most part transverse to the direction of the pull. As the stretch becomes greater oblique systems of lines on other grains come into view.

The photograph, Fig. 1, taken from a strip of transformer plate (rolled from Swedish iron and annealed after rolling), gives a characteristic view of these lines as they appear after a moderate amount of permanent stretching, but long before the iron has reached its breaking limit.

The appearance of each grain is so like that of a crevassed glacier, that these dark lines might readily be taken for cracks.

The real character of the lines is apparent when the crystalline constitution of each grain is considered. They are not cracks, but *slips* along planes of cleavage or gliding planes.

Fig. 2 is intended to represent a section through the upper part of two contiguous surface grains, having cleavage or gliding planes as indicated by the cross-hatching, AB being a portion of the polished surface. When the metal is pulled beyond its elastic limit, in the direction of the line A B, yielding takes place

FIG. 1.—Soft sheet iron strained by tension. 400 diameters.

by finite amounts of slips occurring at a limited number of places in the manner shown at *a*, *b*, *c*, *d*, *e* (Fig. 3). This slip exposes short portions of inclined surfaces, and when viewed under normally incident light, these surfaces appear black because they return no light to the microscope. They are consequently seen as dark lines or narrow bands, extending over the polished surface in directions which depend on the intersection of the polished surface with the surfaces of slip.

We have proved the correctness of this view by examining these bands under oblique light. When the light is incident at

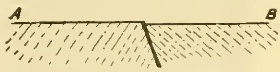


*Fig. 2. Before straining.*

only a small angle to the polished surface, the surface appears for the most part dark; but here and there a system of the parallel bands shines out brilliantly in consequence of the short cleavage or gliding surfaces which constitute the bands having the proper inclination for reflecting the light into the microscope. Rotation of the stage to which the strained specimen is fixed makes the bands on one or another of the grains flash out successively, with kaleidoscopic effect. In what follows we shall speak of these lines as slip-bands. Fig. 1, through a mixed illumination, shows some of the slip-bands bright and some dark.

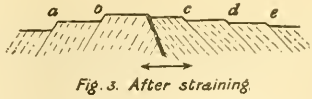


*Fig. 3. After straining.*

When the metal is much strained a second system of bands appears on some of the grains, crossing the first system at an angle, and in some cases showing little steps where the lines cross. These bands are clearly due to slips occurring in a second set of cleavage or gliding surfaces. Occasionally a third system of bands may be seen.

When the experiment is made with a polished but unetched specimen the slip-bands appear equally well. The boundaries of the grains are invisible before straining; but they can be distinguished as the strain proceeds, for the slip-bands form a cross-hatching which serves to mark out the surface of each grain.

Fig. 4 is another sample of iron strained by pull. The specimen in this case was a bar of Swedish iron, in which a comparatively large crystalline structure had been developed by annealing for some hours at 700° C. The photograph was taken after the bar had been broken in the testing machine, and shows with a magnification of 400 diameters a portion of the surface not far from the place of fracture.

The slip-bands are developed by compression as well as by extension. The bands developed by compression have apparently all the characteristics which they present in stretched pieces, and we could not, by microscopic examination of the surface, distinguish in this respect between the effects of compression and extension.

By twisting an iron bar well beyond the elastic limit the slip-bands are made to appear, for the most part, in directions parallel and perpendicular to the axis of twist.

A strip of sheet metal, such as iron or copper, in the soft state, when bent and unbent in the fingers, shows them well developed by the extension and compression of the surface.

These experiments throw what appears to us to be new light on the character of plastic strain in metals and other irregular crystalline aggregates. Plasticity is due to slip on the part of the crystals along cleavage or gliding surfaces. Each crystalline grain is deformed by numerous internal slips occurring at intervals throughout its mass. In general these slips no doubt occur in three planes, or possibly more, and the combination of the three allows the grain to accommodate itself to its envelope of neighbouring grains as the strain proceeds. The action is discontinuous: it is not a homogeneous shear but a series of finite slips, the portion of the crystal between one slip and the next behaving like a rigid solid. The process of slipping is one which takes time, and in this respect the aggregate effect is not easily distinguishable from the deformation of a viscous liquid.

We infer from the experiments that "flow" or non-elastic deformation in metals occurs through slip within each crystalline grain of portions of the crystal on one another along surfaces of cleavage or gliding surfaces. There is no need to suppose the portions which slip to be other than perfectly elastic. The slip,

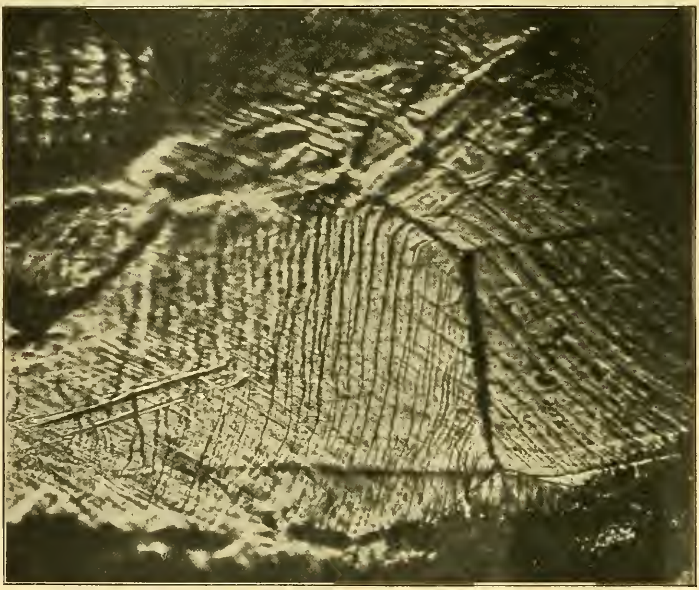

FIG. 4.—Swedish iron, much strained. 400 diameters.

when it occurs, involves the expenditure of work in an irreversible manner.

It is because the metal is an aggregate of irregular crystals that it is plastic as a whole, and is able to be deformed in any manner as a result of the slips occurring in individual crystals. Plasticity requires that each portion should be able to change its shape and its position. Each crystalline grain changes its shape through slips occurring within itself, and its position through slips occurring in other grains.[1]

The experiments were made in the engineering laboratory at Cambridge, and are being continued. The authors express their indebtedness to Sir W. Roberts-Austen and Mr. T. Andrews for advice as to the preparation of specimens of metals for microscopic examination.

We have developed the slip-bands in iron, steel, copper, silver, gold, nickel, bismuth, tin, gun-metal, and brass. In gold and silver they show particularly well, the crystalline structure being large and the lines straight. In copper also the lines are straighter and more regularly spaced than is general in iron. Most of these metals have been tested in the form of blocks under compression. A beautiful development of slip-bands may readily be produced by pinching a button of polished silver or copper in a vice, or by bending a strip of sheet metal.

In carbon steels we have found the slip-bands considerably more difficult to observe than in wrought iron. The smaller granular structure of steel apparently makes the slip-bands correspondingly minute. In mild steel they are seen readily enough, but in a rather high carbon steel we succeeded in seeing them only with difficulty in the "ferrite" areas under a magnification of 1000 diameters. A cast piece of the nearly pure iron used for dynamo magnets showed a relatively very large granular structure and well marked slip-bands.

[1] Attention should be called in this connection to the experiments of Messrs. McConnel and Kidd on the plasticity of glacier ice (*Roy. Soc. Proc.*, vol. xliv. p. 331). They found that bars cut from glacier ice which is an aggregate of irregular crystals are plastic.

April 27.—"On the Luminosity of the Rare Earths when heated in vacuo by means of Kathode Rays." By A. A. Campbell Swinton. Communicated to the Royal Society by Lord Kelvin, F.R.S.

For incandescent gas mantles it is found that certain definite mixtures of the rare earths are necessary in order to obtain the maximum luminosity. For instance, a mantle consisting of pure thoria or pure ceria will in the Bunsen flame only give about one-eleventh of the light of one composed of 99 per cent of thoria and 1 per cent of ceria, which is the mixture used by the Welsbach Company.

In order to explain this remarkable fact, several contradictory theories have been propounded, and with a view to elucidating matters the author has made experiments in which mantles composed of different pure oxides and mixtures were heated by kathode ray bombardment in vacuo.

The mantles were prepared according to the ordinary Welsbach process, and in order to obtain accurate comparisons the mantles were made in patchwork, each complete mantle being made up of two or four sections separately impregnated with different solutions. The mantles were so mounted in the vacuum tube that the kathode rays impinged equally upon the portions that consisted of different oxides and mixtures, so that an equal amount of energy was imparted to each sample. Under these conditions the Welsbach mixture of thoria plus 1 per cent. of ceria was found to give very little more light than pure thoria, the difference probably not exceeding 5 per cent., but on starting the kathode discharge the mixture heated up to incandescence more rapidly, and on stopping the discharge cooled more rapidly than the pure thoria. At the same time it was found that with an intensity of kathode rays that gave a brilliant light both with pure thoria and with the Welsbach mixture, a mixture of 50 per cent. thoria and 50 per cent. ceria, and also a piece of mantle composed of pure ceria, gave practically no light, becoming barely red-hot.

The maximum luminosities could only be obtained at a critical and highly unstable degree of vacuum, which rendered accurate photometrical measurements impossible, but with pure thoria the amount of light under favourable conditions was estimated at at least 150 candle-power per square inch of incandescent surface, this being obtained with an expenditure of electric energy at about 8000 volts pressure of approximately one Watt per candle.

The kathode rays were found to have a reducing action on the oxides, which became discoloured under the bombardment, the discoloration disappearing owing to re-oxidation on the admission of a small quantity of air. Air so admitted while the tube was working was rapidly absorbed, and after the process of admitting air and absorbing it had been repeated several times, the degree of exhaustion which gave the maximum incandescence was found to have altered considerably, the residual gas having apparently become less conducting.

In place of air, oxygen and hydrogen were separately used as the residual gas, but without any difference in the luminosity.

These experiments show that thoria and ceria, both alone and mixed, behave quite differently when heated by kathode ray bombardment than when heated in a Bunsen flame. In the latter thoria plus 1 per cent. of ceria gives many times as much light as pure thoria alone, while when incandesced by kathode rays of equal intensity the difference, though in a similar direction, is only just appreciable. Again, in the flame, pure ceria gives just about the same amount of light as pure thoria, while with a given intensity of kathode ray bombardment thoria gives a brilliant light, while ceria gives practically none. In arriving at any satisfactory theory of the luminescent properties of the rare earths, these results will have to be taken into account.

"A Quartz Thread Gravity Balance." By R. Threlfall and J. A. Pollock.

The balance is of the horizontal, stretched, quartz thread type. One end of the thread is attached by soldering to a spring of peculiar construction; the other end is attached to the axle of the vernier arm of a sextant. At the centre of the thread a bit of brass wire is attached by soldering, so that the thread crosses the wire, which is about two cm. long, at right angles. The centre of gravity of the bit of wire, which will be referred to as the "lever," lies a little to one side of the thread, so that when the thread is untwisted the lever hangs vertically. The thread is stretched so that, in spite of the weight of the lever, it hangs almost horizontally. To make this arrangement into a gravity balance, it is only necessary to turn the lever round the thread as axis, so that each half of the latter receives about three turns ($3 \times 360$ degrees) of twist. The lever is adjusted till, under these circumstances, it hangs nearly horizontally. A discussion of the theory of the balance shows that if the twist be now reduced the centre of gravity of the lever will rise and the position of the lever become unstable soon after its centre of gravity rises above the horizontal plane through the thread. The nearly horizontal position of the lever is secured during observation by means of a microscope, which can be focussed upon the end of the lever, and which is rigidly attached to the framework of the instrument. Gravitational attraction on the lever is thus balanced by the torsional rigidity of the quartz fibre, and the observations consist in noting the increase or diminution of twist, as applied at one end of the thread, necessary to bring the lever to its sighted position. The whole apparatus is enclosed in a tube which is air-tight, the vernier axle working through a sort of mercury stuffing-box. Exact thermometry is required, and is supplied by means of a platinum thermometer lying alongside the thread.

The instrument only gives relative values of gravity, referring an excess, or defect, of gravitational force to the difference of gravitational intensity at two stations selected as having known constants, in the present case Sydney and Melbourne.

The difficulties which have been met with during many years' work arise from the warping of the metallic parts of the instrument under changes of temperature and in the imperfect elastic properties of fused quartz threads.

The possible errors of a single observation are shown, from a discussion of the detail of the instrument, to amount to about one part in 300,000 of the value of $g$ at any point, and by a discussion of three journeys between Sydney and Hornsby (N.S.W.), it is shown that the consistency actually realised is about one in 500,000 of $g$.

Many journeys have been made with the instrument in New South Wales, Victoria, and Tasmania, from which the perfect portability of the instrument has been ascertained, as well as its convenience in practice. A single observation takes only a few minutes after the temperature has arrived at a maximum or minimum, but the packing and unpacking occupy more than an hour—in general about three hours are required. The weight of the total outfit, with ordinary appliances just as they came to hand in the laboratory, is 226 pounds, but this might be halved by making the appliances specially. The paper contains the complete theory of the instrument, working drawings exhibiting its construction, and an account of experiments made with various modifications of the instrument.

"On the Electrical Conductivity of Flames containing Salt Vapours." By Harold A. Wilson, B.Sc. (Lond. and Vic.), 1851 Exhibition Scholar. Communicated by Prof. J. J. Thomson, F.R.S.

The experiments described in this paper were undertaken with the object of following up the analogy between the conductivity of salt vapours and that of Röntgenised gases, and especially of getting some information about the velocities of the ions in the flame itself.

They are to some extent a continuation of the research of which an abstract has already been published in the *Proceedings* of the Royal Society ("The Electrical Conductivity and Luminosity of Flames containing Vaporised Salts," by A. Smithells, H. M. Dawson, and H. A. Wilson, *Roy. Soc. Proc.*, vol. lxiv. p. 142).

The paper is divided into the following sections:—

(1) Description of the apparatus for producing the flame.

(2) The relation between the current and E.M.F. in the flame.

(3) The fall of potential between the electrodes.

(4) The ionisation of the salt vapour.

(5) The relative velocities of the ions in the flame.

(6) The relative velocities of the ions in hot air.

(7) Conclusion.

The current with a large E.M.F. was found to be independent of the distance between the electrodes in the flame, provided both were hot enough to glow; it was much greater when the hotter electrode was negative than when it was positive. When both electrodes were hot, the fall of potential between them was found to be very like that observed in the discharge through gases at low pressure. If one of the electrodes was cool, then nearly all the fall of potential occurred very near to it. Practically all the ionisation of the salt vapours appeared to take place at

the surfaces of the glowing electrodes. The velocities of the ions in the flame were estimated by finding the electric intensity required to cause them to move down the flame against the upward stream of gases. The positive ions of all the alkali metal salts had a velocity of about 60 $\frac{\text{cms.}}{\text{sec.}}$ for one volt per cm. The corresponding velocity of the negative ions was about 1000 $\frac{\text{cms.}}{\text{sec.}}$ In a current of hot air the corresponding velocities were as follows:—

(1) Negative ions of salts of Li, Na, K, Rb, Cs, Ca, Sr, and Ba, 26·0 $\frac{\text{cms.}}{\text{sec.}}$

(2) Positive ions of salts of Li, Na, K, Rb, and Cs, 7·2 $\frac{\text{cms.}}{\text{sec.}}$

(3) Positive ions of salts of Ca, Sr, and Ba, 3·8 $\frac{\text{cms.}}{\text{sec.}}$

The greater velocity of the negative ions enables the phenomena of unipolar conduction &c., to be easily explained.

**Physical Society**, May 12.—Prof. Perry, Vice-President, in the chair.—Dr. Lehfeldt read a note on the vapour pressure of solutions of volatile substances. The change in vapour pressure of a solvent due to the solution in it of a small quantity of volatile material has been calculated on the basis of Raoult's rule for the corresponding case of a non-volatile dissolved body. The author has interpreted the formula of Nernst in the following words:—When a small quantity of volatile substance is dissolved in a liquid the vapour pressure of the liquid is altered in the ratio of the molecular fractional amount of solvent in the liquid to that in the vapour. In order to test this formula, it has been applied to the results of experiments made on four series of liquids, viz. alcohol with benzene and toluene, and carbon tetrachloride with benzene and toluene. In the case of normal solutions, such as carbon tetrachloride in toluene, carbon tetrachloride in benzene, and benzene in carbon tetrachloride, the agreement between the observed and calculated values of the percentage composition of the liquid was remarkably good. In the case of toluene in carbon tetrachloride the solution contained about 29 per cent. of the dissolved body; and as the range of applicability of the formula had probably been exceeded, the agreement was not so good as in the previous examples. The mixtures containing alcohol show maxima of vapour pressure, and on this account the departure from the formula is so much more marked that it is impossible to apply it except in the case of very dilute solutions. The temperature used throughout the experiments was 50° C.—The Secretary read a note by Prof. W. B. Morton and Dr. Barton on the discussion of their paper, on the criterion for an oscillatory discharge of a condenser. In the discussion which followed the reading of the paper, it was pointed out that the result obtained, viz. that on taking into account the distribution of the current in the wire—a condenser having the critical capacity on the simple theory gives an oscillatory discharge—seems to be contradicted by the well-known fact that the resistance of the wire is greater and the inductance less for oscillatory than for steady currents. The explanation of the apparent paradox is to be found in the effect of the damping on the inductance. When the damping is great and the frequency small, as in the neighbourhood of the critical case, what may be termed the equivalent inductance becomes greater than the steady current value. It is shown that this increase in "L" outweighs the increase of "R" in its effect upon the criterion for oscillatory discharge. An examination of the expression for the equivalent inductance in the case of iron shows that it is greater than the steady current value if the ratio of one amplitude to the next is greater than $e^{n/200}$ where $n$ is the frequency of the oscillation. Since the decrease of "L" with maintained oscillations is due to a surface concentration of current, it is suggested that there must be an axial concentration in the case of damped vibrations. Following the method of Maxwell for determining the current density at a distance from the axis of a wire, an expression for the current was introduced containing a damping coefficient. The "quasi-amplitude" of the disturbance at any point in the wire was thus obtained. An examination of the result shows that making the damping zero indicates a surface concentration. If, on the other hand, the damping is great, the expression for the amplitude increases as the distance from the axis decreases, and we get an axial concentration. Assuming sufficient damping to produce this effect, it is shown that as we go through the point $r = \frac{a}{\sqrt{2}}$, where $a$ is the radius of the wire, we pass from a greater value of current density in the inner parts to a less in the outer than would correspond to a uniform distribution throughout the wire. From general reasoning the authors think that if a rapidly damped disturbance is propagated into a wire from its boundary, and if the oscillations are slow enough to allow the current to penetrate to the core, we should expect to find an axial concentration in the latter stages of the phenomenon. Dr. Lehfeldt said that Prof. Lodge had pointed out, at the reading of the paper, that the solution the authors obtained changed character at the critical resistance. As this point had not been considered in the note, he supposed that the change in character made no difference to the results obtained. The Chairman expressed his interest in the proof of the existence of an axial concentration.—Mr. Addenbrooke exhibited and described a quadrant electrometer for application to alternating current measurements. The author has substituted for cylindrical quadrants two sets of flat plates, the top set being adjustable. In this way the range of the instrument is considerably increased. The ability to remove one or more of the top quadrants makes the needle very accessible. By lowering the needle on to the bottom quadrants, and then bringing down one of the top plates, the instrument can be carried with safety. One of the top quadrants can be worked up and down by a worm gear, and by this motion the "electrical zero" of the electrometer is obtained. The suspension consists of a flat phosphor bronze strip, the torsion of which is found to be perfectly uniform, there being no fatigue effect. The case of the instrument contains windows, so that the needle can be viewed from two directions at right angles, and there are screw motions to centre the needle with respect to the quadrants. To reduce the effect of air convection currents upon the needle, the inside of the case is lined with cotton velvet. The quadrants are supported on brass bars passing through long ebonite sleeves in the bottom of the instrument. This gives good insulation without the use of sulphuric acid, and there is no Leyden jar or condenser in connection with the needle. When using the electrometer idiostatically with the finest strip, a light needle, and the quadrants one-tenth of an inch apart, a difference of potential of one volt will produce a deflection of about 5 mms. upon a screen two metres distant. Using the instrument heterostatically with 100 volts on the needle one-fifth of an inch between the quadrants and half a volt acting across them a deflection of 200 mms. can be obtained. This sensitiveness is about twelve times as great as that got from instruments designed by Kelvin, Mascart, and Haga. Mr. Addenbrooke then showed how, in conjunction with a voltmeter and an ammeter, it was possible with his instrument to determine all the factors of an alternating current system. The increased sensitiveness of the electrometer renders it possible to measure currents of any magnitude with a very small waste of energy. Mr. Gaster pointed out that the measurement of self-induction with an electrometer could only be carried out practically if the current curve was a sine curve. He said that in curves obtained from a Ganz motor a correction amounting to 7 per cent. had to be applied. The Chairman said that even if the curve obtained was a sine curve, the electrometer was never used in this country for measuring self-induction. Prof. Herschel asked if it were possible to adjust the quadrants after the needle had been charged Mr. Addenbrooke then purposely disturbed the position of the adjustable plate, and, after charging the needle, reduced the deflection to zero by the worm gear. The author said that for high voltages the curve of calibration was different to that obtained from the ordinary formula. The Chairman said that this discrepancy was probably due to want of perfect symmetry. In a paper read before the Royal Society by Perry, Ayrton and Mather, it was shown that the presence of the guard around the mirror of an ordinary electrometer was sufficient to affect the needle when working with high voltages. In working with the plates very close together he was afraid the symmetry would be liable to be disturbed by a slight tilting of the needle due to electrostatic attraction. The author observed that the plates were only very close together when working with low voltages.

**Chemical Society**, May 4.—Prof. Thorpe, President, in the chair.—The following papers were read:—On the combustion of carbon disulphide, by H. B. Dixon and E. J. Russell. Carbon disulphide undergoes a phosphorescent combustion in air at temperatures below its ignition point, the lowest observed

value for which was 232°; prolonged heating of carbon disulphide at 230°, or prolonged exposure to bright light, causes slight decomposition. The decomposition of carbon bisulphide vapour by detonation is not propagated as an explosion, and no explosive wave could be propagated in mixtures of the vapour and oxygen containing less than 40 per cent. of the latter.—The action of nitric oxide on nitrogen peroxide, by H. B. Dixon and J. D. Peterkin. A very slight increase of volume occurs on mixing nitric oxide with nitrogen peroxide at 27°, but a considerable expansion attends the mixing of inert gases like nitrogen with the peroxide, owing to dissociation of the latter; these results may be explained by the equation

$$N_2O_3 \rightleftarrows NO + NO_2$$

on the supposition that at 27° the dissociation is nearly complete.—On the mode of burning of carbon, by H. B. Dixon. It is shown that Lang's view that carbon dioxide is the first product of the combustion of carbon, and that carbon monoxide is only produced by the subsequent reduction of the dioxide, is invalid.—Crystalline glycollic aldehyde, by H. J. H. Fenton and H. Jackson. The aqueous syrup containing glycollic aldehyde obtained by heating dihydroxymaleic acid with water, yields a hexose, $C_6H_{12}O_6$, on evaporation; during the latter process a small proportion of crystalline glycollic aldehyde sublimes; when first dissolved in water the aldehyde has the composition $C_4H_8O_4$, but after about twenty-four hours the molecular composition becomes $C_2H_4O_2$.—On the blue salt of Fehling's solution and other cuprotartrates, by O. Masson and B. D. Steele. The blue salt of Fehling's solution when dried *in vacuo* has the composition $K_3C_{12}H_9Cu_4O_{19}$, $4H_2O$, and contains a complex negative radicle of which copper is a part; none of the copper is electropositive.—The preparation of acid phenolic salts of dibasic acids, by S. B. Schryver.—The maximum pressure of naphthalene vapour, by R. W. Allen. The author has prepared, from new experimental data, tables showing the vapour pressure of naphthalene and giving the weight of naphthalene required to saturate a cubic metre of gas at temperatures ranging from 0° to 130°.—Scoparin, by A. G. Perkin. Scoparin, the colouring matter of broom, s probably a methoxyvitexin.—On a new compound of arsenic and tellurium, by E. C. Szarvasy and C. Messinger. The compounds of arsenic with elements of the oxygen-sulphur series which are most stable at high temperatures are $As_2O_3$, $As_2S_2$, $As_2Se$; since the differences between the molecular weights in this series of compounds are 15 and 16, it was thought probable that the compound $As_2Te_3$ should be formed at high temperatures. The authors have obtained this compound.—The action of hydrogen peroxide on secondary and tertiary aliphatic amines. Formation of alkylated hydroxylamines and oxamines, by W. R. Dunstan and E. Goulding.—The enantiomorphously related tetrahydroquinaldines, by W. J. Pope and S. J. Peachey. The authors have separated synthetic tetrahydroquinaldine into a dextro- and a lævo-rotatory isomeride by crystallising its salts with camphorsulphonic acids.

**Entomological Society**, May 3.—Mr. R. McLachlan, F.R.S., in the chair.—Dr. A. L. Bennett exhibited various insects which he had collected in the French Congo. They included a species of Mantidæ remarkable for its very striking resemblance in coloration to a piece of bark.—Mr. F. Enock exhibited a living specimen of *Nepa cinerea* infested with a number of minute red *Acari* on the ventral surface of the abdomen. He also showed eggs of *Nepa* and *Notonecta* lying *in situ* in decayed leaf-stalks of *Alisma*, and described the mode of oviposition as observed by himself in both of these genera. He then exhibited a living example of the remarkable aquatic Hymenopteron—*Prestwichia aquatica*, Lubb., and said it was one of a brood of nine, including eight ♀♀ and one ♂, that issued on May 1 from a single egg of *Colymbetes* found on September 5, 1898.—Mr. Merrifield showed some specimens of *Hemaris bombyliformis*, Esp., with the scales still covering the central portions of the wings. He said these scales, which are present immediately after the emergence of the insect but soon become detached, may be rendered adherent by allowing a very weak solution of indiarubber in benzoline to run over the wings.—Mr. C. H. Dolby-Tyler communicated a paper on the development of *Ceroplastes roseatus*, Towns. and Cockl.

**Mathematical Society**, May 11.—Prof. H. Lamb, F.R.S., Vice-President, in the chair.—Major MacMahon, R.A., F.R.S., communicated some results he has obtained in the theory of partitions.—Mr. H. M. Macdonald read a paper on the zeroes of aspherical harmonic, $P_n^m(\mu)$, considered as a function of $n$.—Mr. W. F. Sheppard gave an account of his paper on the statistical rejection of extreme variations, single or correlated (normal variation and normal correlation).

MANCHESTER.

**Literary and Philosophical Society**, April 25.—Mr. J. Cosmo Melvill, President, in the chair.—At this the annual general meeting, Mr. R. H. Inglis Palgrave, F.R.S., and Prof. William Ramsay, F.R.S., were elected honorary members of the Society.—The annual report (as amended) and the statement of accounts were adopted, and the following were elected officers and members of the Council for the ensuing year:—President, Prof. Horace Lamb, F.R.S.; vice-presidents, Prof. Osborne Reynolds, F.R.S., Mr. Charles Bailey, Mr. J. Cosmo Melvill, and Prof. W. Boyd Dawkins, F.R.S.; secretaries, Mr. R. F. Gwyther and Mr. Francis Jones; treasurer, Mr. J. J. Ashworth; librarian, Mr. W. E. Hoyle; other members of the Council, Prof. H. B. Dixon, F.R.S., Mr. Francis Nicholson, Mr. J. E. King, Mr. R. L. Taylor, Mr. F. J. Faraday, and Mr. W. H. Johnson.—At the ordinary meeting held afterwards, Prof. Dixon described an apparatus for bringing together nitrogen peroxide and nitric oxide in order to determine whether any combination occurs between the gases.

PARIS.

**Academy of Sciences**, May 8.—M. van Tieghem in the chair.—On the absolute measurement of time, deduced from the laws of universal attraction, by M. G. Lippmann. The unit of time suggested is based upon the proposition that the numerical value of the Newtonian constant is independent of the units of length and mass, and depends uniquely upon the choice of the unit of time. Inversely, the magnitude of the interval of time taken as unity is determined without ambiguity when the numerical value of the Newtonian constant which corresponds to it is given.—Anatomical and physiological characters of plants rendered artificially Alpine by alternation between extreme temperatures, by M. Gaston Bonnier. Alpine temperature conditions were imitated by keeping the plants in an ice box during the night, and exposing fully to the sun during the day. The petioles of the leaves develop more rapidly under these conditions, and the leaves, which are smaller and thicker, have a more highly developed layer of pallisade tissue, and frequently the reddish coloration of Alpine plants. The flowers are relatively larger and more highly coloured than those grown under ordinary conditions.—M. Prillieux was elected a member of the Botanical section, in place of the late M. Naudin.—On the circumstances which modify the images reflected by a mercury bath, and on the transmission through the soil of vibrations produced at the surface, by M. G. Bigourdan. In the hope of securing a steadier mercury surface, the bath was placed at varying distances from the surface of the earth. It was then found that two quite distinct classes of earth tremors could be distinguished, the one slow and regular, to which the name undulation is given, the other rapid and irregular vibrations.—On the pencils which correspond to the case where the series of Laplace is limited in one direction, by M. C. Guichard.—The groups of the order $p^2q^2$, $p$ being a number greater than $q$, by M. Le Vavasseur.—On the electric capacity of badly conducting bodies, by MM. I. I. Borgmann and A. A. Petrovsky.—On an intense source of monochromatic light, by MM. Ch. Fabry and A. Perot. The new source suggested is the electric arc between two surfaces of mercury *in vacuo*. The mercury is contained in two concentric glass tubes, the inner one only just separating the two mercury surfaces. On giving the tube a slight shock a momentary connection is set up, and the arc starts. For a perfectly stable arc a potential of about thirty volts is necessary, and a current of from two to three amperes. The light is not perfectly monochromatic, but may be easily rendered so by the interposition of cells containing suitable absorption media. Thus, a mixture of didymium chloride and potassium bichromate cuts off all rays except the green ray, the most useful ray for general purposes.—On the ratio of the atomic weights of hydrogen and oxygen, by M. A. Leduc. By taking into account the increase of pressure observed to take place when hydrogen and oxygen gases are mixed, the number for the ratios of the atomic weights deduced from the density of detonating

gas (15·898), is increased to 15·878, a number sensibly in agreement with the 15·88 found by the author by the gravimetric method.—On the increase of pressure produced by the mixture of two gases, and on the compressibility of the mixture, by M. Daniel Berthelot. The formulæ proposed by the author in a previous paper are applied to the gas mixtures, $SO_2+CO_2$, $N_2+O_2$, and $H_2+O_2$, and the results compared with the experiments of Sacerdote, Leduc, Rayleigh, and the author. The agreement is very close.—Researches on the separation of traces of bromine existing in chlorides, by M. H. Baubigny. A strong solution of the chloride, to which a large amount of copper sulphate has been added, is treated with potassium permanganate in the cold, and the whole reduced to dryness *in vacuo*. The whole of the bromine is thus given off, together with a little chlorine; the original method proposed by the author and M. Rivals is then applied to this mixture. Two test analyses show satisfactory results, even when only ·005 gram of bromide was present with 12 grams of chloride.—On the impurities of aluminium, by M. Adolphe Minet.—On magnesium phosphide, by M. Henri Gautier. The phosphide $Mg_3P_2$ was prepared in a pure state by the direct combination of the elements in a stream of hydrogen. Pure $PH_3$ is obtained on treating this with water.—On the flame of hydrogen, by MM. Schlagdenhauffen and Pagel. The violet-blue colour of a hydrogen flame obtained when the gas is prepared from zinc is not due to sulphur, as proposed by Salet, but selenium. Some selenium is invariably left behind in the residue, probably as lead selenide.—Hydrogenation of acetylene in presence of nickel, by MM. Paul Sabatier and J. B. Senderens. A mixture of hydrogen and acetylene acts vigorously upon reduced nickel, even in the cold, ethylene, ethane, and liquid hydrocarbons being produced in quantity.—On the dextrines arising from saccharification, by M. P. Petit.—Method for rapidly measuring the dimensions of small objects, independently of their distance. Application to pupillometry and to laryngometry. Illusion due to the muscular sense in the appreciation of the size of objects, by M. Th. Guilloz.—Pathological physiology of pregnancy, by MM. Charrin and Guillemonat.—The influence of freezing upon the development of the hen's egg, by M. Étienne Rabaud. The eggs were not killed by exposure to $-15°$ C., but the development was markedly affected, and that permanently.—Some remarks on the *Haementeria costata* of Müller, by M. A. Kowalevsky.—On the existence of a fauna of Arctic animals in the Charente at the Quaternary epoch, by MM. Marcellin Boule and Gustave Chauvet.—New researches on the caverns of Padirac, by MM. Armand Viré and Étienne Giraud.—On the ascent of the *Balaschoff* on March 24, by M. G. Le Cadet.

## DIARY OF SOCIETIES.

*THURSDAY*, MAY 18.

ROYAL SOCIETY, at 4.30.—Bakerian Lecture: The Crystalline Structure of Metals: Prof. J. A. Ewing, F.R.S., and W. Rosenhain.—The Yellow Colouring Matters accompanying Chlorophyll and their Spectroscopic Relations: C. A. Schunck.—The Diffusion of Ions into Gases: J. S. Townsend.—The Diurnal Range of Rain at the Seven Observatories in connection with the Meteorological Office, 1871–1890: Dr. R. H. Scott, F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—Electric Locomotives in Practice and Tractive Resistance in Tunnels, with Notes on Electric Locomotive Design: P. V. McMahon.

CHEMICAL SOCIETY, at 8.—Corydaline, Part VI.: Dr. J. J. Dobbie and A. Lauder.—Oxidation of Furfural by Hydrogen Peroxide: C. F. Cross, E. J. Bevan, and T. Freiberg.

*FRIDAY*, MAY 19.

ROYAL INSTITUTION, at 9.—Runic and Ogam Characters and Inscriptions in the British Isles: The Lord Bishop of Bristol.

EPIDEMIOLOGICAL SOCIETY, at 8.30.—A Study of Enteric Fever in the Netherlands: Prof R. H. Saltet.

*TUESDAY*, MAY 23.

ROYAL INSTITUTION, at 3.—Recent Advances in Geology: Prof. W. J. Sollas, F.R.S.

ROYAL PHOTOGRAPHIC SOCIETY, at 8.—Corea: Mrs. Isabella Bishop.

*WEDNESDAY*, MAY 24.

GEOLOGICAL SOCIETY, at 8.—On the Distal End of a Mammalian Humerus from Tonbridge: Prof. H. G. Seeley, F.R.S.—On Evidence of a Bird from the Wealden Beds of Ansty Lane, near Cuckfield: Prof. H. G. Seeley, F.R.S.—On the Rhyolites of the Hauraki Goldfields (New Zealand): J. Park and F. Rutley.—On the Progressive Metamorphism of some "Dalradian" Sediments in the Region of Loch Awe: J. B. Hill.

*THURSDAY*, MAY 25.

ROYAL INSTITUTION, at 3.—Water Weeds: Prof. L. C. Miall F.R.S.

*FRIDAY*, MAY 26.

ROYAL INSTITUTION, at 9.—Climbs and Explorations in the Andes: Sir W. Martin Conway.

PHYSICAL SOCIETY, at 5.—On the Thermal Properties of Normal Pentane, Part 2: Prof. S. Young and Mr. Rose-Innes.—On the Distribution of Magnetic Induction in a Long Iron Bar: C. G. Lamb.

## BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—Cours Elémentaire de Zoologie: R. Perrier (Paris, Masson).—Chapters on the Natural History of the U.S.: Dr. R. W. Schufeldt (Gay).—Das Tierreich, 7 Liefg.: Profs. Canestrini and Kramer (Berlin, Friedländer).—Ditto, 8 Liefg.: Prof. K. Kraepelin (Berlin, Friedländer).—Electromagnetic Theory: O. Heaviside, Vol. 2 (*Electrician* Company).—The Tides Simply Explained: Rev. J. H. S. Moxly (Rivingtons).—A Manual of Surgical Treatment: Prof. W. W. Cheyne and Dr. F. F. Burghard, Part 1 (Longmans).—Physique et Chimie Viticoles: A. de Saporta (Paris, Carré and Naud).—The Aborigines of Tasmania: H. Ling Roth, 2nd edition (Halifax, King).

PAMPHLETS.—Die Elemente des Erdmagnetismus, &c.: Dr. H. Fritsche (St. Petersburg).—Man the Microcosm: L. Hall, Part 1 (Williams).—Die Lokalisation Morphogenetischer Vorgänge: H. Driesch (Leipzig, Engelmann).—Die Aufstellung der Tiere in Neuen Museum zu Darmstadt: G. von Koch (Leipzig, Engelmann).—Siebenter Jahres-Bericht des Sonnblick-Vereines für das Jahr 1898 (Wien).

SERIALS.—Science Gossip, May (Strand).—Botanische Jahrbücher, Siebr. Bd. 1 and 2 Heft (Leipzig).—Fortnightly Review, May (Chapman).—Zeitschrift für Physikalische Chemie, xxviii. Band, 4 Heft (Leipzig).—Himmel und Erde, April (Berlin).—Natural Science, May (Pentland).—Journal of Botany, May (West).—Observatory, May (Taylor).—Journal of the Chemical Society, May (Gurney).—Geographical Journal, May (Stanford).—Monthly Weather Review, January (Washington).—Proceedings of the Royal Society of Edinburgh, Vol. xxii. pp. 361–440 (Edinburgh).—Engineering Magazine, May (Strand).—Physical Review, March (Macmillan).—Scientia, No. 3 (Paris, Carré).—Journal of Applied Microscopy, March (Rochester, N.Y.).—L'Anthropologie, Tome x. No. 2 (Paris).—Record of Technical and Secondary Education, April (Macmillan).—Memoirs of the Boston Society of Natural History, Vol. v. Nos. 4 and 5 (Boston, Mass.).—American Journal of Mathematics, April (Baltimore).—Psychological Review, May (Macmillan).—National Geographic Magazine, May (Washington).—American Journal of Science, May (New Haven).—Botanischer Jahrbücher, Sechsr. Band, v. Heft (Leipzig).

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THURSDAY, MAY 25, 1899.

## RECENT WORKS ON MEDICAL SCIENCE.

1. *The Administrative Control of Tuberculosis.* Being the Harben Lectures delivered in 1898, before the Royal Institute of Public Health, by Sir Richard Thorne Thorne, K.C.B., F.R.S. Pp. 73. (London: Baillière, Tindall, and Cox, 1899.)
2. *Die Bedeutung der Reize für Pathologie und Therapie im Lichte der Neuronlehre.* Von Dr. A. Goldscheider. Pp. 88. (Leipzig: Barth, 1898.)
3. *Twenty-seventh Annual Report of the Local Government Board*, 1897-98. Supplement containing the Report of the Medical Officer for 1897-98. Pp. 331. (London: Her Majesty's Stationery Office, 1898.)
4. *The Natural History of Digestion.* By A. Lockhart Gillespie, M.D., F.R.C.P., F.R.S. (Ed.) Pp. 427. "Contemporary Science Series." (London: Walter Scott, Ltd., 1898.)
5. *Diet and Food considered in Relation to Strength and Power of Endurance, Training and Athletics.* By Alexander Haig, M.A. and M.D. (Oxon.), F.R.C.P. Five Illustrations. Pp. 86. (London: J. and A. Churchill, 1898.)
6. *On Centenarians and the Duration of the Human Race.* By T. E. Young, B.A., F.R.A.S. Pp. 145. (London: Charles and Edwin Layton, 1899.)

1. THE subject-matter of the Harben Lectures, of which the book before us consists, is at the present time of special interest, not only to the medical profession, but to the general public. The country is now thoroughly roused to the importance of the control of tuberculosis, and although the measures considered in Sir R. Thorne Thorne's book are intended primarily for sanitary officials, they should prove of extreme interest and importance to both the general practitioner and the agriculturist.

In the first lecture, the author emphasises the fact that while of recent years the death-rate from pulmonary consumption has very greatly diminished, no corresponding diminution has been observed in the number of deaths due to tubercular lesions of the alimentary tract. The difference ætiologically between these two classes of cases consists mainly in the air being the source of infection in the former, and the food in the latter. The enormous improvement in the arrangement of dwelling-houses and streets with regard to ventilation facilities and drainage suffices to explain the diminution in the phthisis death-rate. According to the author, the absence of improvement with regard to meat and milk supply goes far to account for the death-rate remaining stationary in tubercular disease of the digestive tract. The foods which, for the most part, are the sources of tubercular infection are meat and milk. So far as concerns meat, which is far the less important of the two, the author advises the establishment and exclusive use of public slaughter-houses under administrative control. In these slaughter-houses experts could decide to what extent the flesh of tuberculous beasts was unfit for human food. It is interesting in this connection to note that beasts bred in confinement—*i.e.* with a diminished fresh air supply—are most frequently the subjects of tuberculosis, the disease in wild animals being very rare.

The second lecture is practically devoted to the consideration of milk as a source of tubercular infection. The vast majority of cases of tabes mesenterica (tubercular disease of the intestines) occur at precisely that period of life which corresponds to the maximum milk consumption, viz. early childhood. The deaths under one year of age, returned as due to this cause, amounting to no less than 1·046 per million births. This, according to the author, is in great part due to the prevalence of tuberculosis among milch cows. In England and Wales there are 2,100,000 milch cows, and of these 525,000 are tuberculous. The rejection of al tuberculous cows is impracticable. The administrative control of cow-houses, especially with regard to the amount of cubic space per cow, would, according to the author, greatly lessen this appalling amount of disease. So long as the cow-house remains filthy, the burnished cleanliness of the dairy is unavailing.

The third lecture discusses the *pros* and *cons* of the compulsory notification of phthisis, and is of less interest to the readers of NATURE, although of profound importance to the expert.

The space at our command has only enabled us to touch upon a few of the many interesting points in these lectures. A thorough perusal of them will repay both the general and the special reader.

2. This book is an interesting monograph devoted to the study of the importance of stimuli of various kinds in different disorders of the nervous system. The author's contention is that the effect of the various stimuli, such, for instance, as massage, friction, electric stimulation, &c., which are now used very generally therapeutically, can be explained physiologically, and therefore that these methods must be regarded as part of the legitimate *repértoire* of the physician.

The first chapter is devoted to the physiology of the subject. The author adopts the neuron theory of the nervous system, and goes a step further in that, according to him, each anatomical unit is also a unit physiologically. The unit of nerve activity he terms the neuron wave (Neuronschwelle). Chapter ii. treats of the pathological changes in the neuron waves. A relatively small part of the book is devoted to the explanation of how external stimuli, applied with a therapeutical object, act in certain cases of hyperæsthesia and paralysis. The author thinks that the effect of external stimuli in these conditions is not entirely explained by merely assuming that they form the afferent impulse of a vascular reflex action, but that they also act by disturbing in one or other direction the equilibrium of the excitations (Erregungen) at the time existing in the nervous system. In conclusion, the author considers that the varied phenomena occurring as the result of so-called "suggestion" are all explicable upon this "physiological neuron" hypothesis, and hence are robbed of any mysticism which, from a legitimate medical practice standpoint, seriously restricted the use of this method.

The monograph is to the general physiological reader

somewhat abstruse, and the style involved, but should be of considerable interest and importance to the neurologist.

3. This report contains a mass of interesting fact; the parts of it, however, most likely to be appreciated by the readers of NATURE are the reports contained in Appendices A and B. These are generalised in the report proper as Auxiliary Scientific Investigations. One of the most interesting of these treats of the relation of enteric fever to oysters. The Medical Department was successful in tracking at least twenty-six cases of enteric fever to infection by Brightlingsea oysters. It was also ascertained that, during 1897, infectious matters derived from persons suffering from enteric fever must needs have been discharged in the immediate neighbourhood of certain oyster beds situated in Brightlingsea Creek. The Urban District Council of Brightlingsea are now taking measures which will obviate this pollution of their oyster-beds.

Dr. Klein reports upon bacillus enteritidis sporogenes. This anærobic bacillus occurs under certain conditions in milk, and has a casual relation to infantile diarrhœa.

Dr. Sidney Martin furnishes a report on the viability of the typhoid bacillus in virgin and organically polluted soil. This research, so far as concerns the ability of the typhoid bacillus to thrive in soils containing other bacteria, is at present incomplete.

A short report deals with the relative values of the chemical and bacterioscopic methods of water analysis; from this it appears that, in the case of waters very slightly contaminated with sewerage, chemical methods gave negative results when bacilli could be detected in probably harmful quantity.

Some further interesting observations upon the streptococcus scarlatinæ have been made. It appears that this organism, which is the cause of scarlatina, may haunt the nasal secretion of patients long after desquamation has ceased and recovery has taken place.

4. The "Contemporary Science Series," so well known to the general scientific reader, has, in including this work in its publications, acted very wisely. It is quite impossible in a short notice, like the present, to give any adequate account of the contents of Dr. Gillespie's book. The subject is treated from a thoroughly scientific standpoint, and yet at the same time is made essentially readable even to the general reader. The only two faults to be found with the book are that, firstly, it is too condensed, and secondly, no doubt for the sake of saving space, the complete references to the literature of the subject are not always quoted. Names are from time to time mentioned without the full reference. This fault is somewhat accentuated by the absence of a bibliography, the mere list of authors being actually of little service. The book is thoroughly up to date, and although there is no attempt at making it in any sense a practical handbook, sufficient of the practical is introduced to give point and interest to the descriptive.

In the chapters upon such subjects as foods, alcohols, &c., the author shows a wise discrimination, and does not allow himself to be the mouthpiece of any of the many varieties of faddism which exist. A biological survey of digestion such as the present, containing a description of digestion in plants, as well as in animals, is certain to be of value to the biologist. The chapter on ferments contains an account of the most recent researches in this field. Numerous diagrams and tables, the latter containing a mass of information, add to the value of the work.

5. Dr. Haig's book may be regarded as an appendix to the author's earlier work on "Uric Acid." Many of the views expressed therein, and reiterated here, are not generally accepted either by physiological chemists on the one hand, or by physicians on the other. It is well to make this fact quite clear, as the general reader, into whose hands this book will probably fall, may be apt to think that what the author states as "shown" or "proved" in "Uric Acid" is universally accepted fact. The obstruction of the peripheral capillary circulation by uric acid may be quoted as an instance of this; it is well to emphasise the fact that this is pure imagination. Further, the poisonous properties ascribed to uric acid and the xanthins are by no means established. To the readers of "Uric Acid," such expressions as "a rush of a lot of uric acid into the blood" will be familiar. "A lot" of uric acid has never been demonstrated in the blood under any circumstances, and such an expression must be regarded as highly unscientific and misleading. Upon premises akin to the above and a few experiments, the author recommends what may be termed ultra-vegetarianism; that is, a vegetarian diet from which eggs are excluded, also tea, coffee, alcohol and tobacco. The book is written in a popular style, and it is to be feared that the plausibility of the manner and the attractiveness of the title, by increasing the circulation of the book amongst the public, will tend rather to the perpetuation of faddism than to the advancement of knowledge.

6. This work is a critical and an historical inquiry into a subject which *ipso facto* is of universal interest. The author lays great stress upon the stringent nature of the proof which must be exacted in the case of any claim to having acquired very advanced age. The methods adopted by the Institute of Actuaries may be regarded in this respect as a standard. Some score of examples of centenarians, authenticated beyond all doubt, is given; but the author rejects such instances as William Parr, to whom tradition ascribes the age of 157 years, as unproved. An interesting chapter is devoted to a consideration of the enormous age of the Biblical patriarchs, various hypotheses being advanced in explanation of this. The book concludes with some interesting speculations concerning a possible law of longevity. The author has taken considerable pains to sift well the literature of his subject, and if the whole is not as concise as perhaps it might be, the book contains much that is interesting and instructive.

F. W. T.

## ROUTH'S DYNAMICS OF A PARTICLE.

*A Treatise on the Dynamics of a Particle.* By Edward John Routh, Sc.D., LL.D., M.A., F.R.S., &c. Pp. xi + 417. (Cambridge University Press, 1898.)

THIS treatise is intended for the student. It has all the merits as well as the limitations which characterise Dr. Routh's other well-known text-books; and, on the principle of reserving the good wine to the last, we will first consider its limitations, more particularly as an introduction to dynamical science.

It is, however, a doubtful point whether the author intends this treatise to be an introduction; for, although he gives, on p. 3, the usual *elementary* demonstration of the "parallelogram of velocities," he continues:—

"This rule is the same as that given in statics for compounding forces which act at a point. Hence all the rules of Statics, which are derived from the parallelogram of forces, will also apply to velocities. We may therefore infer the triangle of velocities, and all the various rules for resolving and compounding velocities, both by rectangular and oblique resolutions."

The logical conclusion from this remarkable demonstration is that the student is supposed to have studied statics before he has ventured into the shiftier ways of what Dr. Routh calls dynamics. This, of course, is not the Newtonian method; yet the whole fabric is avowedly based on the laws of motion. Fortunately, the student able to enter upon a study of this book is, in all probability, well-grounded in the fundamental principles of dynamics, and will skim through the opening sections too quickly to suffer serious contamination. The very first section will, nevertheless, certainly startle him, for there he learns that

"the science of dynamics is divided into two parts. In one the geometrical circumstances of the motion are considered apart from the physical causes of that motion; in the other the mode in which the motion is produced by the action of forces is investigated. The first is usually called *kinematics*, the second is called sometimes *kinetics* and sometimes *dynamics*."

It passes comprehension that a mathematical writer dealing with the most exact of the exact sciences should have the audacity to adopt a nomenclature which virtually makes the part equal to the whole. The source of the confusion is obvious enough. It is a result of halting between two opinions. The expressive word kinetics is adopted, but statics is ignored as a *branch* of dynamics.

The same clinging to the inconvenient and occasionally illogical nomenclature of a past in which Newton was only half understood is noticeable in other parts of the book, and recalls irresistibly Maxwell's verse:

"The phrases of last century in this
Linger to play tricks—
*Vis Viva* and *Vis Mortua* and *Vis Acceleratrix*."

Dr. Routh has a strong affection for *Vis Viva*, in spite of the fact that physically it is half this quantity that is the important thing. To be thoroughly consistent he should call twice the potential energy *Vis Mortua!*

A short section is devoted to so-called *accelerating force*, the origin of which is explained in a rather curious way. It is derived from the equation $F = mf$, and is stated to be the quotient $F/m$. "It is equal to the acceleration, and the word 'force' appears to have been added merely to show from which side of the equation the quantity is derived." The author is apparently ignorant of the fact that this unnecessary phrase is a pedantic translation of Newton's Latin term.

In a neighbouring section, we read that "the theory of work is so much used in statics that only a very brief account is necessary here." This brings us face to face again with a serious blemish of treatment. What logical right has Dr. Routh, in laying the foundations of dynamics, to take statical principles for granted? Does not the parallelogram of forces spring directly from the *definition* of force; and is not that definition ultimately kinetic? Moreover, in a *purely* statical problem forces can do no work; and the introduction of the principle of work into statics is a confession that statics cannot be treated apart from kinetics. In the discussion of certain general dynamical principles (*e.g.* what is too commonly called D'Alembert's), it is usual to appeal to the principles of equilibrium, which have already been established on a sound kinetic basis; but such an appeal is obviously out of place in the treatment of dynamic fundamentals.

Dr. Routh's discussion of Newton's laws of motion is probably the least satisfactory part of the book. There is no clear indication of what is really definition and what is experiential inference in these laws. One term at least is introduced before it is defined, and there is, from time to time, a looseness of language inappropriate to a mathematical treatise. For example, speaking of the momentum of a body, the author says "it may be compounded" by the parallelogram law—compounded, what of, or what with? Within four lines Atwood's "machine" is referred to as a "problem" and as an "experiment." Atwood's machine in the concrete is probably useful enough in *illustrating* to immature minds the meaning of inertia and the law of gravity at the earth's surface; but more it *cannot do*, and any quantitative experiment with it is worthless. As a source of problems to vex the pupil, Atwood's machine in the abstract is of perennial value to the weary examiner.

In § 65 we read:

"The law of gravitation asserts that the forces of attraction of the earth on different bodies at the same place are proportional to the masses of those bodies. This is true whatever be the materials of which the body is made. . . . This is an experimental fact which is independent of the laws of motion. . . . The law of gravitation asserts that $g$ is constant at the same place on the surface of the earth. It is sometimes called the constant of gravitation."

There seems to be a subtle confusion here. The *experimental fact* is that the acceleration due to gravity at any assigned place on the earth's surface is the same for all bodies. The laws of motion *then* enable us to make the first statement quoted above. As for the inconstant $g$, what possible claim can it have to the high sounding title of the constant of gravitation? Such a nomenclature has sprung from half knowledge; and, if referred to at all (for which, however, there was no necessity), should have been at once condemned with all the authority of a master.

The impression we gain from a perusal of Chapter i. is that Dr. Routh has never seriously considered the logical foundations of the science of dynamics, and has probably never had to deal with students really beginning their studies. Once he gets fairly into the heart of the subject, he rises for the most part distinctly above criticism. Beginning, in the usual way, with examples of rectilinear motion (Chapter ii.), he passes on to motion of projectiles, constrained motion in two dimensions, motion in two dimensions, central forces, motion in three dimensions, and finishes with a chapter on "some special problems." To each chapter is appended a

selection of examples well fitted to test the student's progress. Many of these examples are of the familiar "academic" character, having little reference to natural phenomena; but from time to time, and particularly in the chapter on central forces, we meet with problems of high interest and importance. The effect of planetary perturbations on comets and the disintegration of comets into meteor swarms may be specially mentioned. Then the question of the stability of orbits is discussed at considerable length.

Here and there, however, a few points seem to call for remark. In § 222, Dr. Routh finds it convenient to introduce the term *vector*. It would have greatly facilitated his earlier work had he introduced the term at the very beginning. The conception of a vector quantity in mathematical physics is one which every student should get as soon as possible. It should be impressed upon his mind from the very start as something fundamental and far-reaching, and not merely as a convenient term enabling us "to avoid the continual repetition of the same argument."

The title of § 135 is "Discontinuity of a centre of force"—a most extraordinary collocation of words, and absolutely misleading. There can be no discontinuity of a *centre of force*; the discontinuity (if the term be used at all) is in the incomplete mathematical expression of the solution.

A certain looseness of expression is also apparent in the titles of §§ 186, 187, which are respectively, "Work of a central *force*," and "Work of an elastic *string*."

In Chapter vii. Lagrange's equations are introduced, and a variety of interesting problems in three dimensions discussed, *e.g.* motion of a particle constrained to move on a tortuous curve or on a surface. The case when the surface is an ellipsoid is investigated at considerable length, several of Liouville's results being introduced as examples for solution by the student.

Chapter viii. is devoted to "Some special problems," a title, however, which is a most incomplete description of its contents.. The brachistochrone may, in a sense, be called a special *problem*, but, as developed by Tait, Townsend and others, its theory is of a very general character, and abounds in *theorems* of great interest. Following this there is a fairly complete discussion of the motion of a particle relative to the earth when the earth's rotation is taken into account—a problem of no small importance. After a few sections on inversion and conjugate functions, the final "special problem" taken up is Hamilton's theory of action. We doubt if any student, not otherwise instructed, could gather from Dr. Routh's pages the great importance of Hamilton's contributions to general dynamic theory. On p. 394 we read: "These are called *the Hamiltonian Equations of Motion*"; but there is no direct reference whatsoever to Hamilton, and in the index, under Hamilton's name, we find references to "Law of force in a conic" and to "Hodograph," but none to "Action"! In a book, one of whose really valuable features is its system of historic notes, such an omission is inexplicable. In striking contrast there is *full* recognition of the merits of Jacobi, who, as Hamilton himself expressed it in a letter to Andrews, "enriched by his comments" Hamilton's theory. One recommendation the student will do well to follow: let him refer to his "Thomson and Tait." The enunciation of Tait's problem (p. 401) contains a misprint which reduces the statement to an absurdity.

It is a reproach frequently cast by literary men that scientific writers lack style. There is not much scope for a cultivation of style in a mathematical treatise, but surely we have a right to expect good English. In the book before us there occurs with painful frequency the fault of the misrelated participle. On p. 7, an indefinite "it" is found "assuming the principles of the differential calculus"; on p. 145, a (dynamic) couple is represented as "remembering" something; on p. 150, the work done by forces is found capable of "selecting some geometrically possible arrangement," and so on.

By way of general summary we may, in conclusion, remark that, although the first chapter is open to serious criticism, and the book is somewhat marred throughout by a looseness of diction, Dr. Routh's "Treatise on the Dynamics of a Particle" is an important contribution to the literature of the subject. To the working student its value is enhanced by a well-selected stock of examples, many of which appear for the first time in a formal treatise. Some of the problems specially considered are of high interest, and the solutions in many cases are of practical value. In a word, the book fully sustains the reputation of its author as an experienced teacher, now bringing forth from his treasure-house things old and new, and appealing to a wider circle of ardent disciples who will be found wherever the English tongue is heard. C. G. K.

## *LABORATORY MANUALS OF INORGANIC CHEMISTRY.*

*Qualitative Chemical Analysis.* By Chapman Jones. Pp. 213. (London: Macmillan and Co., Ltd., 1898.)

*Practical Inorganic Chemistry for Advanced Students.* By Chapman Jones. Pp. 239. (London: Macmillan and Co., Ltd., 1898.)

*Advanced Inorganic Chemistry.* By G. H. Bailey, D.Sc., Ph.D. Edited by William Briggs, M.A. Pp. 333. (London: W. B. Clive, 1898.)

THE first of the above books appears as one of the well-known series of "Manuals for Students." The tradition of these books is that they are not primarily written for a syllabus, but rather that an author has here an opportunity of developing his own ideas, and producing a book which has individuality. We turn, therefore, with considerable interest to this addition to an already abundant literature to see how far the author has contributed anything new or valuable to analytical teaching. As far as we can gather, the great defect which Mr. Chapman Jones believes to attend the study of analysis is that the student's mind is apt to get filled with a knowledge of isolated reactions, whilst really

"the use of such exercises, as are given in the laboratory, is to the would-be chemist exactly what the practising of exercises and scales is to the young musician. The aim is not merely to perform the exercise, but to do it in such a manner that it shall be practice in a thoroughly sound method of work."

It appears, therefore, that Mr. Chapman Jones sets his mind essentially on producing a correct executant.

Further evidence of this appears in the tables of separations, which are printed on parchmentised paper, and open out on each side of the stitching,

"so that if anything is spilled on to the book as it lies open at any of the tables, the result will not be so disastrous as it otherwise might be,"

and the underlying pages will be protected. This certainly suggests scale practising. Taking the author's purpose as he states it, we have carefully read the book and examined the methods prescribed. We believe certainly that the analytical methods are sound; but we should hesitate to say that, in this respect, this book is superior to a dozen others that could be named. It is written undoubtedly by one who has a mature knowledge of his subject, and the processes described satisfy all reasonable requirements in point of accuracy; but we find hardly anything noteworthy in the mode of presenting the subject or in the details—nothing certainly that will warrant us in saying that this is conspicuously *the* book for a sound method. In other respects, it makes no special claim. The sections of "Comparative Remarks" on the elements or radicals of a group are likely to be useful, but as an exposition of the theory of analysis as well as the practice the book leaves much to be desired.

Mr. Chapman Jones' second book is written to suit the syllabus of the Science and Art Department for practical inorganic chemistry in the advanced stage. The analytical part of it is adapted from the work just noticed. The rest includes the preparation of gases and some volumetric analysis. As all the topics of the syllabus are dealt with, the book will no doubt suit its immediate purpose. The mode of treatment calls for remark in one particular only. The preparations are grouped as follows:—Preparation of gases by the use of cold liquids, ditto by the use of hot liquids, ditto by the heating of dry substances, preparations involving distillation, preparations made in solutions. A protest must be entered against a mode of classification so entirely divorced from educational purpose. Even if there were practical convenience in it, which we do not admit, that would by no means justify a sequence of experiments dictated by considerations of merely having this or that piece of apparatus handy for use.

A book entitled "Advanced Inorganic Chemistry," written for "The Organised Science Series," and containing in the preface a statement that a certain liberality of treatment (of chemical physics) is justified by the importance attached in the syllabus to the subject, is calculated to raise prejudice in the mind of a reader. We make haste to say, therefore, that Dr. Bailey's book contains very little evidence, if any, of having been written to conform to a syllabus, or to provide information in that highly compressed and uninspiring form, which until recent times has seemed to prove most suitable for meeting the requirement of the Science and Art Department. The book begins with a short account of the properties of gases, including a good account of Avogadro's hypothesis, of dissociation, and of the methods of determining the composition of gases. In stating that equal volumes of *all* gases . . . contain the same number of molecules, the author, we think, underlines the wrong word. The whole advance made by Avogadro is surely embodied in the word *molecules*: it was not the introduction of the idea of equal numbers (as beginners are so often taught), nor the mere extension of an existing generalisation. The chapter on the atomic weights of the elements is excellent in most respects, but we regret to see the statement that a measure of the chemical attraction or affinity exerted between two elements is afforded by the heat developed by their union. An unqualified statement of this kind is calculated to instil a fundamentally wrong idea of the relationship between heat and chemical affinity. In the main part of the book dealing with the elements and their compounds, the mode of treatment is broad and luminous, and the information is well selected. Some few deficiencies in detail are to be found; but, on the other hand, there are many little features in which the book is an improvement on others of like scope. The following points are, perhaps, worth noting. Cryohydrates are mostly mixtures of ice and salt, and not definite compounds, as implied on pp. 60 and 67. On p. 103, the production of iodine by the action of sulphuric acid on potassium iodide may be better explained by the reducing action of hydriodic acid on sulphuric acid than by the mere decomposition of the hydriodic acid *per se*. The preparation of silicon from silicon dioxide and of boron from boron trioxide by means of magnesium, and also the preparation of silicon hydride, easily demonstrated in test-tubes, are not mentioned, nor is justice done to the energetic properties of boron. The preparation of potassium chlorate by electrolysis of potassium chloride is not mentioned; and though the electrolytic preparation of sodium is described, the figure which illustrates the process is hardly comprehensible. Three useful appendixes on crystallography, spectrum analysis, and chemical calculations, and a series of chemical problems, conclude the book. Owing to some printing accident, the appendix on spectrum analysis ends prematurely in the middle of a sentence. A. S.

## THE MODERN BICYCLE.

*La Bicyclette: sa Construction et sa Forme.* Par Dr. C. Bourlet. Pp. 228. (Paris: Le Génie Civil; Gauthier-Villars, 1899.)

THIS is a reproduction of a series of articles which appeared in vol. xxxiii. of *Le Génie Civil*, and forms, in some measure, a supplement to the author's "Nouveau Traité des Bicycles et Bicyclettes." With the exception of an appendix on the theory of ball-bearings, the present work is non-mathematical in character, and is addressed to all cyclists who take an intelligent interest in their machines. The first chapter is devoted to an historical summary, then follow chapters on the frame, steering, bearings, gearing, change-speed gears, wheels and tyres, tricycles, accessories, and hygiene of touring.

The work is to be warmly welcomed, as adding to the far too scanty independent literature on the construction of the bicycle. We feel somewhat at a loss, however, as to the standpoint to be taken in reviewing the book. In the historical portion many events which, on this side of the Channel at least, are regarded as of primary importance are not even referred to—*e.g.* Kirkpatrick

Macmillan and Gavin Dalzell's construction of a practical rear-driver, the appearance of the original Dunlop pneumatic tyre with outer cover cemented to the rim, while free-pedals are merely referred to as incidental accompaniments of automatic brakes. Dr. Bourlet's history of the introduction of pneumatic tyres reads like a burlesque :—

". . . The first pneumatic tyres were very timid attempts, and at the best only suitable for racing tracks. . . . The single tube tyres, Clincher, Boothroyd, and others then became popular, and were a little more trustworthy. . . . It was not until Michelin put on the market his detachable tyre that pneumatic tyres entered the domain of practical cycling mechanics. . . . Six months later the Dunlop Company exhibited a detachable tyre. . . ."

Again, in the purely descriptive portions of the book many important developments of the last three or four years are entirely unnoticed ; to wit, Lloyd's cross-roller gear, the Fleuss and Trench tubeless tyres, jointless hollow rims, short-pitch roller chains, the Bowden brake transmitting mechanism ; in fact, the book is at the date of its publication several years behind the times, as far as the bicycle in England is concerned.

The discussion of the various points of construction are very interesting and instructive ; but the conclusions drawn by the author are in many cases diametrically opposed to opinions widely held on this side of the Channel. The author has proved that, for ease of steering, the frame of a good bicycle should be as short as possible ; the frame with extended wheel-base "était donc détestable ; il manquait d'ailleurs de rigidité." The frame of the Pedersen bicycle, weighing less than 20 lbs. complete, receives most praise ; but the author would improve it by substituting pin-joints for the rigid lugs. Mr. Mushing's analysis in the Centaur Company's catalogue of the weight of a bicycle equipped as a heavy roadster and as a road racer (total weights 36 lbs. and 25 lbs. respectively, weight of frame and front forks in each case 7 lbs. 15 oz.) might modify the author's opinion on this point.

In chains, a retrograde movement was effected when, in 1895, English makers returned to the detestable block chains, "un peu modifiées, il est vrai, mais toujours aussi mauvaises." Now, whatever be the merits of the 1899 roller chains, the old inch-pitch roller chains were much worse than the block chains which superseded them. Has the author compared, say, a Hans Renold block chain with the roller chains made prior to 1895? The type of roller chain held up for admiration is that with each sleeve split at the middle, a half-sleeve being made as a solid internal projection from each inner side-plate. This construction is thoroughly bad, and no chain made in this way is durable, as some chain-makers have found to their cost.

A great number of two-speed gears are described, none of which have been sold to any extent in England, while the few two-speed gears known here are not referred to. This chapter is therefore of interest mainly to the mechanician and the designer.

As a practical guide to the cyclist in choosing a new machine, the book will be of most service in France, but of little or no value here. A. S.

## OUR BOOK SHELF.

*The Spirit of Organic Chemistry.* By Arthur Lachman, B.S., Ph.D. With an Introduction by Paul C. Freer, M.D., Ph.D. Pp. ix + 229. (New York : The Macmillan Company. London : Macmillan and Co., Ltd., 1899.)

The title of the book, if it conveys a definite idea, scarcely explains the contents. The preface, however, sets forth the various objects which the book is intended to accomplish. Its main purpose, we are told, is to supplement the text-book and to introduce the student to the current literature of the subject, from which it is to be inferred that he will be equipped with a sufficient knowledge of present problems to follow contemporary research.

The volume consists in reality of a series of essays on subjects which have at one time or another engaged the attention of chemists. It is divided into chapters, the heading of each furnishing the text for a discourse on some prominent theory or classical investigation. "The constitution of acetoacetic ether" leads up to an account of *tautomerism*. The constitution of the sugars, of maleic and fumaric acids, of the oximes and of the diazobenzene compounds, involve a series of dissertations on stereochemical problems ; whilst the chapters on uric acid and the constitution of rosaniline record the development of certain branches of synthetic chemistry. An essay on the constitution of benzene, and a brief history of "Perkin's reaction," complete the series. The subjects are not by any means exhaustively treated ; but they are presented in an easily readable form, and controversial matters are handled in a judicial spirit.

Whether these few essays will enable the student to follow current literature is another question. A great amount of organic research is now busy with the constitution of the terpenes, the camphors, the alkaloids, the artificial and natural colouring matters, and many other subjects of which no word is said. Moreover, several of the subjects discussed have passed into history. Still, there will doubtless be many to whom the volume should prove interesting and profitable reading.

The introductory chapter does not add substantially to the value of the book. Its rather high-sounding phrases convey little real information, and the historical references are too brief to be intelligible to any one ignorant of the history of the science. J. B. C.

*Elementary Physics and Chemistry. First Stage.* By Prof. R. A. Gregory and A. T. Simmons, B.Sc. Pp. viii + 150. (London : Macmillan and Co., 1899.)

The importance of experimental science teaching in elementary schools is being more and more recognised by the Education Department every year. This tendency is seen in the course of elementary physics and chemistry for the upper standards, which was introduced into the Elementary Education Code for 1898. To meet the want thus created is the purpose of the present book, covering the first of the three parts into which the syllabus is divided. The plan of the book is admirable, and though the division of each lesson into "what to do," "reading lesson," and things "to be remembered," involves a certain amount of repetition, there will be compensation to young students in the resulting clearness. Matters are so arranged that the lessons are suitable for classes in which each pupil can perform the experiments for himself, or for those in which they can be made by the teacher alone. In their anxiety to secure a logical sequence of thoughts, the authors have included a few experiments, the results of which we think might have been taken for granted ; but, apart from this, the book seems well adapted for beginners in science. The clear and simple language, combined with a large number of excellent illustrations, can surely leave no doubt in the mind of the dullest pupil as to the ideas which are intended to be conveyed.

## LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### Mangroves Growing in Japan.

HAVING resided for some years in the eastern part of Japan, and having travelled from time to time in various parts of the island of Kiusiu, and from thence to the Farther Isles within the southern boundary of the Luchuan Archipelago, I have noticed that the tropical and sub-tropical types in the Japanese flora are much more marked than has hitherto been supposed. As an instance of this, a selection from the types of mangroves will probably be of more interest, not only to botanists, but also to all lovers of nature, than a list of plant-names.

FIG. 1.—Thickets of *Kandelia Rheedii*, Wight et Arn., growing together with *Pinus densiflora*, Sieb. et Zucc., found on the sides of a stream at Kiiré in Satsuma, Japan. (Reproduced from an original photograph taken by Prof. K. Mitsukuri.)

The northernmost limit of the mangroves in Japan is found in the coast of Kiiré at Satsuma in Kiusiu, where the only species represented is *Kandelia Rheedii*, Wight et Arn. The occurrence of the mangrove in that place is of high interest to geographical botany, inasmuch as that familar representative of tropical vegetation is found there actually intermingled with that of the temperate flora, *Pinus densiflora*, Sieb. et Zucc. This curious and interesting combination is shown in the accompanying illustrations, which were reproduced from the original photographs by Prof. K. Mitsukuri of the Imperial University of Tokyo. Fig. 1 is a fair representation of an outlet of the stream along the coast in the Bay of Kagoshima. Both sides of the stream are studded here and there with the low thickets of *Kandelia Rheedii*, Wight et Arn., among which the evergreen *Pinus densiflora*, Sieb. et Zucc., stands with its outstretching branches. A little further along the coast discloses a finer view (Fig. 2) of the mangrove, forming dense thickets in front; on the background upon the ridge of the hill, a range of *Pinus densiflora*, Sieb. et Zucc., is seen in the distance.

FIG. 2.—View of the coast near Kiiré with the thicket of *Kandelia Rheedii*, Wight et. Arn., in front.

Coming to the island of Amami-Ōshima, the mangroves are common. Here, besides *Kandelia Rheedii*, Wight et Arn., another interesting species, *Bruguiera gymnorhiza*, Lam., makes its appearance. I may here state that Döderlein was, I believe, the first European botanist who collected these species in Japan (vide *Botanisches Centralblatt*, viii., 1881, p 30, and Engler's *Botanische Jahrbücher*, vi., 1885, p. 63).[1] If we proceed again and come to the island of Uchinā or the Lūchū Proper, and from thence to the Yayeyama Archipelago, which is situated close to Formosa, we find in these islands an additional species, *Rhizophora mucronata*, L. It is in the Yayeyama Archipelago that the mangroves exhibit their full development. In the island of Irumuti, the largest among the Yayeyama Archipelago, they often exceed ten feet in height, and exhibit the characteristic feature of the "mangrove forests" (*Mangroven-Wälder*) of the tropical coasts, so admirably described by A. F. W. Schimper ("Die indo-malayische Strandflora," Jena, 1891) and by Karsten ("Ueber die Mangrovenvegetation in malayischen Archipel," Cassel, 1891). Besides, *Avicennia officinalis*, L., and *Sonneratia alba*, L., the well-known associates of the mangroves, are now recorded to grow in the Yayeyama Archipelago.

I observed, in the last-mentioned archipelago, that the fruit of the mangroves when ripe, produces, as is well known, hypocotyl, which soon develops and elongates, and that, in *Rhizophora mucronata*, Lam., it usually becomes 20-40 cent. or more, when the fruit drops on the ground and becomes transfixed. I may also confirm the statement made by Warming (in Engler's *Botanische Jahrbücher*, iv., 1883, p. 519) against the well-known notion that in mangroves the roots produced from the ripe fruits *on* the trees hang down in the air, in the manner of banyan trees, and develop until they reach water, penetrate the mud, and become in time independent trees.

Thus we observe that the three species of the mangroves are at present known to grow in Japan. In conclusion, I may here remark that the thickets of *Kandelia Rheedii*, Wight et Arn., found at the mouth of the river Yawata as well as at the coast between Nukumi and Mayenohama in Satsuma in the Bay of Kagoshima, and also those at Kashiwabara in Osumi, all of which being situated between 31° 18′-31° 23′ N. lat., are, I think, the northernmost limit hitherto known of Rhizophoraceæ.

Tokyo, April 13. TOKUTARO ITO.

### The Development of the Tuatara.

IN the last number of the "Anatomischer Anzeiger" received in New Zealand, there is a paper by Dr. Schauinsland on the development of the Tuatara, confirming the results obtained by Dr. Dendy. A preliminary account of these results has already been published in the *Proceedings* of the Royal Society (vol. lxiii. p. 440), to which Schauinsland makes no reference, although they have been reported in NATURE, while the more detailed memoir was accepted by Prof. Lankester for publication in

[1] The more technical account concerning the determinations of these specimens collected by Döderlein will be published elsewhere.

the *Quarterly Journal of Microscopical Science*, and is, no doubt, by this time in the hands of zoologists.

But it is mere justice to my friend, Prof. Dendy, to place before our European colleagues the following facts in regard to Dr. Schauinsland's reference to the inactivity and lack of enthusiasm exhibited by Colonial zoologists in the matter of this most interesting member of our local fauna.

The Tuatara is quite properly "protected" by the Government of New Zealand; permission to obtain material for the investigation of its life-history was granted to Dr. Dendy, and the lighthouse-keeper on Stephen's Island, a Government servant, was permitted to collect the eggs and embryos for him. But subsequently, and without any communication with Dr. Dendy, and before he had obtained more than a few (if any) eggs, the Government also gave permission to Dr. Schauinsland to collect eggs, and moreover instructed their servant on Stephen's Island to give him every assistance.

In this instance, then, Dr. Schauinsland's charge of lack of enthusiasm is not only baseless. but wanton.

The following fact is not without bearing in this connection. A certain foreign zoologist was recently on a visit to New Zealand for the purpose of collecting the rarer and more characteristic animals, amongst others the Bulimoid pulmonate, *Placostylus bovinus*. Having obtained all the individuals living, as well as shells only, on which he could lay his hands, he proceeded to crush all the young ones he could see, and was heard to remark that if any future zoologist or conchologist wished for a specimen he would have to go to a certain town in Europe (and not to New Zealand).

Dunedin, N.Z., April 13. WM. BLAXLAND BENHAM.

## THE GIPSY MOTH, AND ITS INTRODUCTION INTO AMERICA.

MANY persons, whether entomologists or not, must have noticed a rather slender, dark-coloured moth with feathery antennæ flying among bushes on the continent; and a much larger, stout-bodied, whitish-grey moth, sitting on hedges, or on the trunks of trees. Dissimilar as these insects may appear, they are nevertheless the male and female of the Gipsy Moth (*Porthetria dispar*), the male of which flies about in the day-time like that of the Vapourer Moth (*Notolophus antiquus*), a small tawny-brown moth with a white spot on the fore-wings, which has an apterous female, and the caterpillar of which feeds on a great variety of trees and shrubs (Fig. 1).

The two moths are not distantly related, both belonging to the family *Liparidae*, but while the Vapourer Moth is so common with us that it is often seen flying even in the streets of London, wherever there are any trees near, the Gipsy Moth is now so rare here as to be thought to be extinct in England, though it is abundant, and often destructive, on the continent. The entomologists of the last century speak of it as very rare in England, and as having been introduced into the orchards of Chiswick, where, however, it failed to establish itself. Subsequently, Stephens wrote that it was rare in the neighbourhood of London, though it had been taken occasionally at Coombe Wood, but that it was abundant in the fens of Huntingdonshire. It is very singular that several insects of general distribution on the continent, among which we may specially mention *Papilio machaon*, *Lycaena dispar*, and *Porthetria dispar*, should have ound their last stronghold in England, like the Britons and the Saxons, in the fens, though the Gipsy Moth was formerly common in fens which are still undrained, as well as in some which no longer exist. It is also remarkable that the English fen-specimens of both the butterfly and moth named *dispar* were much larger and finer on an average than the continental representatives of the same species; and that both should have become practically extinct in England since the drainage of the fens.

In 1857, Stainton wrote of the Gipsy Moth: "This species is apparently less common here than formerly," and mentioned Halton in Buckinghamshire, and Stowmarket in Suffolk, as localities. After this time, the moth became rapidly scarcer, and I am not aware that any authentic British specimens have been taken of late years, though a degenerate breed of British origin was preserved among entomologists for a long time, and may be still.

Far different has been the history of the Gipsy Moth in America, where it is not indigenous, though the insect extends across the northern part of Asia-Europe from England to Japan, and is abundant, if not destructive, in most parts of its range.

Thirty years ago, a French entomologist, named Leopold Trouvelot, was living at Medford, in Massachusetts. He was engaged in carrying on a series of experiments on rearing moths, which he thought might possibly be made useful as silk producers. Among other species, he imported the Gipsy Moth, and, by some accident, some of the insects escaped from his custody into his own or the neighbours' gardens. The most

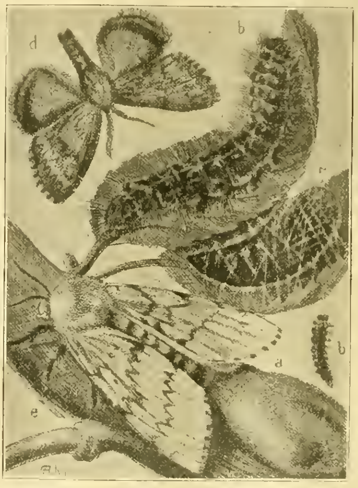


FIG. 1.—Gipsy Moth: *a*, egg mass; *b*, caterpillars; *c*, chrysalis; *d*, male moth; *e*, female moth. (Reproduced from "Insects: Friends and Foes." By Dr. W. Egmont Kirby. Partridge and Co.)

probable story is that some eggs were blown out of the window, and that M. Trouvelot was much concerned at not being able to find them; for the female is a very sluggish insect, which is seldom or never seen on the wing.

Had prompt measures been taken, the insect might possibly have been exterminated; but it does not seem to have attracted any attention till about 1880, when the people then living in or near M. Trouvelot's former residence began to be troubled with swarms of caterpillars, though what they were, and whence they came, was then unknown. For several years the neighbouring houses suffered severely, apple- and pear-trees and shade-trees being stripped of their leaves and killed, and the caterpillars creeping all over and into the houses. Nevertheless, they spread very slowly along the street, and into the surrounding woods till 1889, when the insects multiplied so much that the caterpillars stripped all the trees in the immediate neighbourhood of M. Trouvelot's old house, and then marched forth in

armies sufficient to blacken the streets, in search of fresh provender. A terrible account of the ravages of the caterpillars is given by those who witnessed them, and the town became thoroughly alarmed. Specimens of the insect were sent to the Agricultural Experiment Station at Amherst, Massachusetts, where it was identified by Mrs. C. H. Fernald and her son, in the absence of Prof. Fernald, who happened to be travelling in Europe at the time. On his return, he at once visited Medford, and recommended spraying all infested trees with Paris Green, an arsenical preparation which had previously been employed with great success in checking the ravages of the Colorado Potato Beetle. A pamphlet containing descriptions and figures of the insect in all its stages, with hints for its destruction, was printed and largely circulated; and the veteran agricultural entomologist, Prof. C. V. Riley, gave it as his opinion that if Prof. Fernald's recommendations were carried out at all strictly, there was little fear of the insect spreading, and that it might be entirely exterminated with the expenditure of a little time and money.

Fig. 2.—Destroying the eggs of the Gipsy Moth in the Middlesex Fells Reservation.

In March 1890 a Commission was appointed with full authority to take any necessary measures for the destruction of the pest, and a sum of 25,000 dollars was placed at the disposal of the Commissioners, any person convicted of knowingly spreading the insect, or interfering with the work of the Commissioners, being rendered liable to heavy fines or imprisonment.

As soon as the Commissioners had made a preliminary investigation, it was discovered that the infested area was far larger than had been supposed, and that the grant of 25,000 dollars was wholly insufficient. Large quantities of eggs were destroyed, brushwood cleared, and trees sprayed with Paris Green, while the principal roads leading from the infested district were guarded by policemen, whose duty was to see that caterpillars should not be carried about by passing vehicles.

In 1891, a fresh Commission was appointed, under the auspices of several of the most eminent American entomologists, and Prof. C. H. Fernald was subsequently appointed entomological adviser to the Committee. During the first six weeks of the year, three-quarters of a million egg-clusters were destroyed, estimated to contain from three to five hundred millions of eggs.[1] During the fine season, the trees were sprayed, and in autumn egg-gathering again commenced. Seventy-five thousand dollars were spent this year, and, though the insect was not exterminated, its numbers were seriously reduced. By this time, no less than thirty townships were found to be infested with the insect.

Year by year the campaign against the moth has been continued on similar lines, though impeded by frequent delays in the appropriation grants, as well as by the insufficiency of the amounts, and in 1896 Mr. E. H. Forbush (the field director in the work of destroying the Gipsy Moth) and Prof. Fernald published a volume of 600 pages on the insect and its history, from which much of the information in the present paper is derived. We have also just received the "Report of the State Board of Agriculture on the Work of Extermination of the Gypsy Moth," presented to the Senate and House of Representatives of the Commonwealth of Massachusetts on January 1, 1898, and containing an account of the work of the Committee during 1897. From this we learn that the Committee applied for a grant of 200,000 dollars for the work of that year, and the Legislature promptly granted them three-quarters of the amount. Much work was done (Figs. 2 and 3), and infested districts were cleared as far as the amount would permit, but the Committee's recommendation was for "an appropriation of not less than 200,000 dollars a year for a term of not less than five years, and then an appropriation of not

Fig. 3.—Destroying masses of Gipsy Moth eggs on rocks and ledges.

less than 100,000 dollars a year for a term of not less than five years. After this, an appropriation of perhaps 15,000 dollars a year for a period of five years will be required." On this, Prof. Fernald remarks: "The first five years, with the full appropriation of 200,000 dollars a year, will reduce the territory to such an extent that

[1] These eggs are laid in clusters and covered with down from the abdomen of the female.

with 100,000 dollars a year for the next five years the insect will be practically exterminated, and the remaining five years will be spent in a careful watch of the entire territory, lest a few insects might have been overlooked in isolated localities. Unless a sufficient amount is appropriated to make a very substantial gain each year, it would be better to abandon the work entirely."

It is perhaps not surprising that, after having already spent half a million of dollars in what many persons, rightly or wrongly, considered the hopeless task of exterminating a single insect, the Committee's application for a continuous grant of 200,000 dollars annually should have met with much opposition. A proposal was made to reduce the amount of the grant for 1898 to 75,000 dollars; but it was successfully resisted, and ultimately the full amount of 200,000 dollars asked for was granted for the year.

Another European moth-pest has lately been introduced into America—the Wood Leopard Moth (*Zeuzera pyrina*), which is at present rapidly destroying the shade-trees of New York. But this insect is still more difficult to deal with than the Gipsy Moth, for its naked yellow, black-spotted caterpillar feeds inside the wood of the trees, like that of the Goat Moth, to which it is allied; whereas the black, red-spotted tufted caterpillar of the Gipsy Moth feeds exposed on the leaves of its food-plants.

Different countries exchange their injurious animals and plants from time to time, but no one can tell beforehand which species are likely to establish themselves and to become injurious. We have seen that the Gipsy Moth had ample opportunities of becoming as injurious in England as in America; but, nevertheless, it has died out.

On the other hand, the Woolly Aphis (*Schizoneura lanigera*), which is one of the worst pests of our apple-trees, is said to have come from America, and is often called the American Blight. The vagaries of plants are equally uncertain. Our common water-cress, a harmless plant enough, one would think, has developed a giant form in New Zealand, which is blocking up the water-courses. In the middle of the present century, an American water-plant (*Anacharis alsinastrum*) was introduced into England by some accident, like the Gipsy Moth into America, when it was called the new water-weed, and caused great trouble for a time by choking up rivers and ponds. Fortunately, however, after a few years the plant seems to lose its vitality, and ceases to become a pest, owing, as is supposed, to the female plant only having been introduced into England, and it therefore propagates by buds alone.

Time will show whether the Gipsy Moth will continue its devastations in America, or whether it will either be exterminated by the energetic measures taken for its destruction, or by the conditions of American life proving ultimately unfavourable to it, notwithstanding its first rapid increase. It is evident that, although we cannot avoid the accidental introduction of injurious plants and animals from abroad, some care should be taken in introducing any which might become injurious into another country. M. Trouvelot's experiments were intended to benefit the silk industry in the United States; but they have resulted in letting loose a pest which hundreds of workers are now striving, at enormous annual expense, to eradicate if they can. Let us hope that their efforts may be crowned with success, for otherwise the whole of temperate North America may suffer more or less severely, as the infested districts of Massachusetts are now suffering.

W. F. KIRBY.

## *THE AUSTRALASIAN ASSOCIATION.*[1]

AN Association for the Advancement of Science which can produce, as the record of one year's proceedings, such a volume as the one before us, is at once an indication that a widely-spread interest in science and a vigorous scientific activity already exist, and a promise of future progress. It is a volume on the production of which the Australasian Colonies may be sincerely congratulated.

The Australasian Association for the Advancement of Science held its first session at Sydney in 1888; it next met in Melbourne in 1890; then in Christchurch (New Zealand) in 1891, in Hobart (Tasmania) in 1892, in Adelaide in 1893, in Brisbane in 1895, and in Sydney again in 1898. We do not know whether the fact that only one meeting was held in the five years from 1893 to 1898 was connected with the commercial difficulties through which Australia has recently passed; if so, we trust that the resumption of meetings last year may be taken as a sign of returning prosperity.

The constitution of the Association and the order of proceedings at the general meetings are evidently closely modelled on those of the British Association. The public proceedings begin with an evening address delivered by the President for the year; on the following days, meetings of the several Sections are held, relieved by evening lectures, including one to "working men," conversazioni and concerts, garden parties (with "the number of invitations limited"), Saturday afternoon excursions, and, to wind up the whole entertainment, excursions going further afield. One who is accustomed to the doings at the annual gatherings of the British Association would find himself familiar with the whole programme of its Colonial counterpart. Perhaps he might find his way into a Section whose name and subject he had not been used to in the old country, but he would find most of them just what he was accustomed to, as the following list of Sections will show, namely:—Section A—Astronomy, Mathematics, and Physics; Section B—Chemistry; Section C—Geology and Mineralogy; Section D—Biology, with the sub-departments Botany and Zoology; Section E—Geography; Section F—Ethnology and Anthropology; Section G—Economic Science and Agriculture; Section H—Engineering and Architecture; Section I—Sanitary Science and Hygiene; Section J—Mental Science and Education.

To review with any completeness a volume of over eleven hundred pages, dealing with the almost unlimited range of subjects covered by the ten Sections here enumerated, is obviously impossible. All that we can attempt is to indicate some of what appear to us to be among its more noteworthy contents.

There can be little doubt that the most serious contribution to pure science contained in it is the "Report on our Knowledge of the Thermodynamics of the Voltaic Cell," by Mr. E. F. J. Love. This is a really admirable account of the results that have been obtained, chiefly by Lord Kelvin, Willard Gibbs, and von Helmholtz, by the application of thermodynamic considerations to voltaic phenomena. These results are deduced simply and concisely, and are discussed throughout in relation to the experimental tests to which they have been subjected by various observers. It would, we think, be welcome to many physicists if this paper were reprinted in some more generally accessible publication than the bulky volume before us.

In his presidential address to Section A, Mr. Baracchi, Government Astronomer at Melbourne, gives a very interesting account of the great International Photographic Survey of the Heavens, and especially of the share in this

[1] "Report of the Seventh Meeting of the Australasian Association for the Advancement of Science," held at Sydney, 1898. Pp. lii + 1161.

work undertaken by the Observatories of Sydney and Melbourne. Another part of his address is devoted to urging the importance of a systematic magnetic survey of the Australasian Colonies,and establishing a permanent magnetic observatory in New Zealand. Among other communications to this Section, we may mention an elaborate account of the Trigonometrical Survey of New South Wales, by Mr. T. F. Furber. This work is apparently being carried out with great judgment and skill. The author gives a comparative table, showing the mean errors of the angles in a large number of surveys carried out in Europe, the United States, and elsewhere, which seems to justify him in saying that "The above figures speak for themselves in showing that our work is probably equal to that done in any part of the world." A tide-predicting machine, described by Captain A. Inglis, seems to be recommended by simplicity of construction; the periodic components are represented by templates cut to accurate sine-curves, with appropriate differences of wave-length, which are all fed through the machine at the same speed.

Naturally Australasian fauna and flora, geography and geology, supply material for a large number of descriptive papers. Among these, "A short Dichotomous Key to the hitherto known Species of Eucalyptus," may be remarked. The author, Mr. J. G. Luchmann, identifies no less than 140 species of this, the most important Australian genus of timber-trees. In connection with this paper, we may mention a timely and very earnest protest by Mr. W. S. Campbell against the wantonly improvident destruction of forest trees which is, unfortunately, so common in Australia, as well as in the United States and Canada.

Some of the fundamental questions of social economy, including the production and distribution of wealth, are ably dealt with by Mr. R. M. Johnston, Government Statist of Tasmania, in a presidential address to the Section of Economic Science and Agriculture. Some of Mr. Johnston's conclusions by no means coincide with what are at present fashionable in certain circles in this country, as will be evident from the following quotation: "It is the country which relatively places the smallest number of hands on the land for the production of food and raw products which has also attained the highest stage of progress. . . . I deny, therefore, most emphatically that whatever distress in the United Kingdom still exists would be lessened by any scheme which would place more hands on the land than its economic conditions demand for the production of food and raw products."

The social conditions of the Colonies apparently encourage a relatively great development of governmental participation in industrial operations. After giving some interesting records of his experience as Engineer-in-Chief of Railways and Public Works in South Australia, Mr. A. B. Moncrieff strongly urges the adoption, by the different Colonies, of a uniform system of preparing estimates and keeping records of public engineering work; for, as he rightly points out, in the absence of such a system it is not possible to institute fair and useful comparisons between the works carried out by the engineers of the different Colonies, such as are needed to promote a healthy rivalry among them. The work undertaken for supplying water for agricultural purposes over large areas of dry country seems likely to have very important and beneficial results. Mr. Moncrieff gives some interesting particulars of these operations, and mentions one boring that has been carried to a depth of 3000 feet, which yields 800,000 gallons per day of excellent water at a temperature of 176° F.

A large proportion of the most interesting papers in the volume, including most of those we have mentioned, are due to men who are at the head of various official departments. If the authors of these papers may be taken as fairly representative of their colleagues, we think there is ground for congratulating the Australasian Colonies on the intellectual quality of their chief officials. It appears clear that these men do not rely for departmental efficiency on a blind following of routine, but on an intelligent recognition of the conditions under which they are placed, and of the true nature of the facts with which they have to deal.

Taking the volume as a whole, it gives evidence of solid progress achieved and assurance of future advance.

## SIR FREDERICK McCOY, K.C.M.G., F.R.S., &c.

IN the death of Sir Frederick McCoy, geological science loses one of its most devoted and enthusiastic disciples, one who in early life was associated with Sedgwick in the preparation of that classic work, the "Synopsis of the Classification of the British Palæozoic Rocks; with a systematic description of the British Palæozoic Fossils in the Geological Museum of the University of Cambridge," a quarto volume published in 1855.

Sir Frederick McCoy was the son of Dr. Simon McCoy of Dublin, in which city he was born in 1823. He was educated at the Universities of Dublin and Cambridge, and intended at first to devote himself to the medical profession, but natural history, and the study especially of fossil organic remains, absorbed his chief attention. When but eighteen years of age he had prepared and published a Catalogue of Organic Remains exhibited in the Rotundo, Dublin. Later on, he assisted Sir Richard Griffith in his researches on the fossils of the Carboniferous Limestone of Ireland, and afterwards they prepared a joint "Synopsis of the Silurian Fossils of Ireland," which was issued in 1846. In the same year, McCoy went to Cambridge to help Sedgwick, and we learn (from the "Life and Letters" of that eminent professor) that the new assistant devoted himself for at least four years "uninterruptedly and with unflinching zeal" to the determination and arrangement of "the whole series of British and Foreign Fossils" in the Museum. In 1850, he was appointed Professor of Geology in the Queen's College, Belfast. Meanwhile, he continued to labour at the great work previously mentioned, and which associates the names of Sedgwick and McCoy in the minds of all students of the Cambrian and Silurian rocks. This work was barely finished when McCoy, in 1854, accepted the newly-founded Professorship of Natural Science in the University of Melbourne.

Apart from the larger works to which he had contributed while in this country, McCoy had published numerous papers dealing with fossil Fishes, Crustacea, Echinoderms, Corals, and Foraminifera. He was indeed well prepared for the arduous and successful labours which he now undertook in a new home. Becoming associated with the Geological Survey of Victoria, he established the "Prodromus of the Palæontology of Victoria; or Figures and Descriptions of the Victorian Organic Remains," issued in decades, and he contributed many palæontological reports for the Survey. He also founded the Melbourne National Museum. His latest contribution to science, "Note on a New Australian *Pterygotus*," was printed in the *Geological Magazine* during the present month.

In 1879, he received the Murchison Medal, which was awarded to him by the Geological Society of London, of which society he became a Fellow in 1852. In 1880, he was elected a Fellow of the Royal Society, and he was one of the first to receive the honorary degree of D.Sc. from the University of Cambridge. In 1886, he was made a C.M.G., and in 1891 he was worthily promoted to be K.C.M.G. It is astonishing to note that, while for fifty-eight years he contributed to palæontological literature, his age at his death in May 1899 should be no more than seventy-six.

H. B. W.

## THE EDINBURGH CHAIR OF PHYSIOLOGY.

THE following is the closed list of candidates for the chair of Physiology in the University of Edinburgh, rendered vacant by the death of Prof. Rutherford: Dr. Wace Carlier and Dr. Noel Paton, Edinburgh; Prof. Reid, Dundee; Prof. Schäfer, London; Prof. G. N. Stewart, Cleveland, Ohio; Prof. Stirling, Manchester; Prof. Anderson Stuart, Sydney.

The Edinburgh chair of Physiology, though founded in 1742, has almost invariably been occupied by physicians —amongst others Cullen, Gregory, Alison, and Rutherford's immediate predecessor, Hughes Bennett. The one striking exception in addition to Rutherford is Allen Thomson, the famous anatomist. Rutherford's time having been largely devoted to teaching, it may be truly said that Edinburgh, from a physiological point of view, has still its spurs to win. Had other counsels prevailed in 1855, Edinburgh might have secured the services of Sharpey, and long ere this been as famous for its physiological as for its anatomical school.

The mistakes of 1855 (when the services of Agassiz, as well as those of the founder of English physiology, were declined) are not likely to be repeated, for it is now sufficiently evident to all concerned that if the Scottish capital is to maintain and extend her medical school, she must fill her Science chairs with men who, in addition to great teaching powers, have gained by their researches a world-wide reputation. As it happens, the Court of Curators, in whose hands the appointment lies, will have the opportunity of largely atoning for the past by placing at the head of the physiological department a pupil of Sharpey's who, by his success as a teacher and worker, has placed himself in the very foremost rank of British physiologists.

In the interests of science and of the great imperial seat of learning, we, with Lord Lister, "venture to express the earnest hope that Prof. Schäfer's paramount claims may receive their due recognition."

## NOTES.

THE second (or ladies') conversazione of the Royal Society will take place on June 21.

AT the next meeting (June 8) of the London Mathematical Society, the President, Lord Kelvin, G.C.V.O., proposes to read a paper "On solitary waves, equivoluminal and irrotational, in an elastic solid." At the previous Council meeting, the election of the sixth De Morgan medallist of the Society will take place, and the announcement of the result will be made to the members present at the general meeting. The presentation of the medal will be made at the annual meeting in November next.

THE International Exhibition of Electricity, organised in celebration of the Volta centenary, was opened at Como on Saturday by King Humbert. His Majesty also opened a national silk industry exhibition, connected with the electrical exhibition. Switzerland was officially represented at the ceremony, and there were also present the Bishop of Como, the Senators and Deputies representing the province in the Italian Parliament, some members of the family of Volta, who was born at Como, a number of scientific celebrities, and a large attendance of the general public. Speeches were delivered by the Mayor, the presidents of the two exhibitions, and Signor Salandra, the Minister of Agriculture, who dwelt on the progress made by Italy in the silk-growing industry.

AN international congress dealing with the prevention and cure of tuberculosis was opened in Berlin yesterday. The Emperor and Empress of Germany are taking the greatest interest in the congress, and her Majesty attended in person at the formal opening of the proceedings in the great hall of the Reichstag by the Duke of Ratibor. Some of the foreign delegates will be presented to the Emperor on Sunday after the termination of the congress. Owing to the Whitsuntide recess, the congress will have the use of the whole of the Reichstag buildings. The *Times* correspondent at Berlin reports that on Tuesday night there was an informal reception of the members and delegates by Princess Elizabeth of Hohenlohe in the main gallery of the Reichstag. The congress will be attended by nearly 2000 persons, including 112 foreign delegates and a great number of unofficial foreign members.

IT is announced in *Science* that Mr. Edward H. Harriman, of New York, has invited a number of scientific men to accompany him as his guests on an expedition to Alaska. The party will leave Seattle about the end of May, on a large steamer chartered and fitted up specially for the expedition. They expect to take the "inside passage" route to Lynn Canal, and then, after visiting Sitka, proceed westward along the coast to Yakutat Bay, Prince William Sound, Cook's Inlet and Kadiak Island. Numerous places will be visited which are out of reach of ordinary travellers, and stops will be made to admit of scientific work. Steam launches, tents, camp outfit, packers, &c., have been bountifully provided, so that the largest amount of work may be done in the shortest time.

PROF. S. P. THOMPSON, F.R.S., will be the president of the Institution of Electrical Engineers for the ensuing session.

PROF. J. A. FLEMING, F.R S., will deliver one of the evening lectures during the meeting of the British Association at Dover in September. He has selected as his subject, "The Centenary of the Electric Current."

THE steamship *Antarctic*, with the members of Prof. Nathorst's Expedition on board, left Stockholm on Saturday for the east coast of Greenland in search of Herr Andrée and his two companions.

THE Russian members of the Russo-Swedish Expedition for taking meridian measurements at Spitsbergen, left St. Petersburg on Sunday. The leader of the expedition is Captain Sergieffsky.

MR. R. W. FORSYTH, Royal College of Science, South Kensington, has been appointed official reporter to the Physical Society.

AT the last ordinary meeting of the Midland Malacological Society, held in Mason University College, Birmingham, on May 12, the president, Mr. Walter E. Collinge, in the chair, Dr. Henry Fischer, of Paris, and Prof. H. A. Pilsbry, of Philadelphia, Pa., U.S.A., were both elected honorary members of the Society.

THE announcement of the death of Mr. G. F. Lyster at the age of seventy-six will be received with regret in engineering circles. Mr. Lyster was for a long period engineer-in-chief to the Mersey Docks and Harbour Board. He was a dock engineer of great skill and resource, and not the least of his achievements was the designing of a system of sluicing by which the docks on the Liverpool side of the river were provided with deep sills and approaches—an advantage which up to his time it was not considered practicable to secure. Mr. Lyster, who on retiring a few years ago was succeeded by his son, became a member of the Institution of Civil Engineers in 1858, and of the Royal Society of Edinburgh in 1886.

IN the House of Lords on Thursday last, Lord Harris moved the second reading of the Oysters Bill, which provides that it shall be the duty of every county and borough council to ascer-

tain the sanitary condition of oyster layings within the county or borough, and for that purpose enables the inspector to prohibit the removal of oysters from insanitary layings. Power is given to the Local Government Board to act in the event of default by the local authority, and another clause provides that Her Majesty in Council may in certain circumstances prohibit the importation of oysters from foreign countries and British possessions. The Bill was read a second time.

THE Technical Education Board of the London County Council is co-operating with the Asylums Committee in offering a valuable scholarship of 150*l*. a year, tenable for two years, for students of either sex (preferably qualified practitioners) to enable them to carry on investigations into the preventable causes of insanity. The lady or gentleman appointed to the scholarship will carry on investigations in the Pathological Laboratory attached to Claybury Asylum. A similar scholarship has been held during the past two years by Dr. J. O. W. Barratt, who has carried on valuable original investigations into the causes of insanity, many of which have been recently published. Dr. Barratt has recently been appointed pathologist at the Wakefield Asylum, and the scholarship which he has held is therefore vacant. Candidates must be resident in London. Application should be made to the Secretary of the Technical Education Board, 116 St. Martin's Lane, W.C., not later than Wednesday, June 7.

THE second engineering conference of the Institution of Civil Engineers will be held on June 7–9. The proceedings will be opened with an address by the president, Mr. W. H. Preece, C.B., F.R.S., in the theatre of the Institution, and the programme includes meetings of sections for the discussion of important engineering subjects, and visits to various works. There will be seven sections, dealing respectively with railways, harbours, docks, and canals; machinery; mining and metallurgy; shipbuilding; waterworks, sewerage and gasworks; and applications of electricity. Among the subjects to be discussed are the following:—Systems of fog-signalling; causes of earth-slips in the slopes of cuttings and embankments of railways, and how to prevent or remedy them; machine tools, with special reference to American and German practice as compared with English; recent advances in locomotive practice; the relative advantages of different kinds of power for tramways, light railways and motor-car traffic; bye-product coke ovens; the influence of casting temperature on steel; the purification of gas and the conversion of chemical residuals therefrom, including the preparation of cyanogen; effect of waves on breakwaters in different depths of water; the design of breakwaters; modern improvements in coal mining: winding from deep mines; modern practice in gold mining; comparative advantages of electricity, compressed air and steam for mining and manufacturing purposes generally; the use of filtered flood-water; sewage-sludge disposal by natural agencies, including the purification of sewage by means of artificial filters; mechanical traction by electricity; economical transmission and distribution of electricity from a distance; methods of electrical transformation; some non-integrating electric meters.

IN reference to the scientific commission which was appointed a short time ago by the Colonial Office and the Royal Society to investigate the mode of dissemination of malaria, with a view to devising means of preventing the terrible mortality which now takes place among Europeans resident in tropical and subtropical climates, Dr. Patrick Manson, chief medical adviser to the Colonial Office, has made a statement to a representative of the Exchange Telegraph Company. Dr. Manson states that Dr. C. W. Daniels, of the Colonial Medical Service, British Guiana (who first proceeded to Calcutta to familiarise himself with the work which had been carried on by Surgeon-Major Ross for determining the relation of mosquitoes to the dissemination of malaria), has now arrived at Blantyre in the Central African Protectorate, where he has been joined by Dr. J. W. W. Stephens and Dr. R. S. Christophers. At Blantyre, all the resources of the Protectorate will be placed at the disposal of the commissioners, who, before their return to London, will probably pay a visit to the West Coast of Africa.

THE Meteorological Council have notified by a special circular that they have determined that the issue of forecasts for the hay and corn harvests, which have been distributed during the last twenty years, can no longer be made gratuitously, but they will be supplied in the usual form to persons desirous of receiving them, on payment of the cost of the daily telegrams (including porterage) during the period over which the forecasts are issued. These special forecasts are issued in the afternoon, and refer to the following day; the results in previous years have been very satisfactory, the success reaching in some cases over 90 per cent.

OWING to the public improvements in the neighbourhood o. Parliament Street, the Royal Meteorological Society has been obliged to vacate its offices in Great George Street and find accommodation elsewhere. The Council have taken rooms at Princes Mansions, 10 Victoria Street, which have been fitted up to meet the requirements of the Society. On Tuesday evening, May 16, the president, Mr. F. C. Bayard, held an "at home" in these new rooms, which was largely attended by the Fellows. An interesting exhibition of instruments, photographs, &c., was arranged in the various rooms, and there were also several demonstrations by the optical lantern. At the monthly meeting of the Society, held on Wednesday, May 17, Mr. H. N. Dickson read a paper entitled "The mean temperature of the surface waters of the sea round the British Isles, and its relation to that of the air." A paper by Major-General Schaw, C.B., on some phenomena connected with the vertical circulation of the atmosphere, was also read.

FOUR pieces of a meteorite which exploded and fell on the eastern slopes of Mount Zomba, British Central Africa, on January 25, have recently been added to the British Museum collection. The stones weigh respectively 14, 17, 19 and 29 ounces. The *Times* states that when the meteorite fell, an explosion was heard at Zomba, the reverberations lasting for a few minutes afterwards. The detonation was also heard at Chiromo, situated about ninety miles south of Zomba, and at Fort Johnston and beyond, a distance of about seventy miles in the opposite direction. Zomba was thus roughly the centre of the district over which the actual explosion of the meteorite took place. Ten fragments in all were found, the largest weighing 5 lbs. 12½ ozs. As far as at present known, the area over which the Zomba stones fell represents about nine miles long by about three wide, but, inasmuch as the fragments collected are only those which were seen to fall close to people or houses, it appears probable that a large number of stones may have reached the earth.

AN ingenious arrangement, invented by Mr. Walter Jamieson and Mr. John Trotter, for controlling the direction of torpedoes by means of ether waves is described in the current number of the *Electrician*. The apparatus takes several forms, although the method of utilising Hertz waves is more or less the same in various models, the difference being in the method of applying opposing currents to the rudder or steering mechanism. A satisfactory arrangement appears to be obtained by means of two solenoids, into which are sucked iron cores, attached to

the rudder head, the core which is sucked in depending, of course, upon the direction of the current received. Two rods, projecting above the surface of the water, receive the waves, and are in circuit with a coherer of special type, which affects a relay in the usual way. The actual processes involved in steering and controlling a torpedo are somewhat as follows. Let a torpedo, containing a suitable combination of the apparatus mentioned, be launched, say, from a vessel containing the necessary sending apparatus as described. Suppose the torpedo goes off its course. Then, by means of a switch an induction coil is supplied with electric current, and waves or oscillations are generated. These, on reaching the torpedo, pass into the projecting wire, and thence reach the coherer. This operates the relay, closing its secondary circuit. An electric current now flows through a "selector" to one of the solenoids, the iron core is sucked into right or left, and the helm is thus turned. When the torpedo has attained a proper course, the switch is opened and the waves cease. The vibration in the neighbourhood of the coherer restores it to the original resistance, the current passing through it becomes weaker and ceases to affect the relay coil, which therefore opens the secondary circuit and allows the helm to fly back to the midship position. A large model of the apparatus has been constructed, and it is said to work with entire success under all kinds of conditions.

THE Corporation of Bath have appropriated the necessary funds for the cost of tablets to be affixed to houses entitled to be considered as historic in their city. About forty tablets are to be put on houses which have been the homes of distinguished men, or are otherwise of historic interest, and the first of these, affixed to a house which was once the residence of Sir William Herschel, was officially unveiled on April 22 by Sir Robert Ball. The tablet is shown in the accompanying illustration, for which we are indebted to Sir Robert Ball. The inscription reads: "Here lived William Herschel A.D. 1780." In a little workshop at the end of the back garden of this house, Herschel made his Newtonian reflector, and it was from this spot that he discovered Uranus on March 31, 1781. The Bath Corporation is acting wisely in taking steps to remind the citizens of the distinguished men who have lived within their boundary, and thus incidentally added to the reputation of the city.

THE *Physical Review* (vol. viii. No. 3) contains an article, by Mr. J. G. McGregor, on the applicability of the dissociation theory to the electrolysis of aqueous solutions containing two electrolytes with a common ion. The author calculates the theoretical relative amounts of the distinctive ions transferred by the current, and compares them with observed values, for certain complex solutions. Another article, by Mr. J. O. Thompson, describes some experiments relating to the fatigue of metals. It was found by Lord Kelvin, in 1864, that a wire which had been kept vibrating for several hours or days, through a given range, and then left to itself, came to rest much quicker than when set into vibration after it had been for several days at rest. The present experiments are designed to prove that when temperature and initial amplitude of vibration are constant, and when the wire is not unduly loaded, the period and logarithmic decrement are also constant.

AN investigation of Röntgen phenomena by Mr. John Zeleny is also described at length in the *Physical Review*. The results show that during conduction through a gas under the influence of Röntgen rays, convection currents are produced in the gas, which in general move towards the electrodes. These currents are caused by the motion of the free charges existing in the gas. During the conduction, there is a rapid fall of potential within 0·1 mm. from the surface of the electrodes. By exposing the gas to Röntgen rays, the electric force acting upon the electrodes is increased.

MR. W. L. SCLATER, the director of the South African Museum, Capetown, is making arrangements for the preparation of a series of handbooks on the zoology of the southern part of

the African Continent, to be entitled "The Fauna of South Africa," which will be published by Mr. R. H. Porter. The first volume, by Mr. Arthur C. Stark, containing Part i. of the birds, will shortly appear; and the second volume on the mammals, by Mr. W. L. Sclater, is in a forward state. The volumes will be of octavo size, and will be illustrated by numerous woodcuts in the text.

FROM the *Gazette of British Central Africa* we are pleased to learn that the Administrator of Northern Rhodesia has proclaimed the large district known as the "Mweru Marsh," lying on the east side of the lake of that name, as a "game preserve," in which no game-animals are allowed to be shot without special licence. This excellent step will, we trust, tend largely to the preservation of the existence of the elephants and other large mammals frequenting that district, which has lately received rather too frequent visits from British sportsmen. The Mweru swamps will be found fully described by Mr. Croad in the *Geographical Journal* for June 1898. He says the elephant-hunting there is as good as any south of the equator.

WE have received from Herr B. Walter a reprint of his paper on the nature of electric sparks, published in *Wiedemann's Annalen*, 66. The method of investigation adopted consisted in photographing the sparks produced by an induction-apparatus on a moving plate. The diagrams thus obtained under various conditions bear some resemblance to photographs of so-called "ribbon lightning," and show that the electric spark does not consist of a single discharge alone, but of a succession of brush discharges each following in the path of the previous one. In one case, the interval between successive discharges was found to be roughly the ten-thousandth of a second.

PROFS. ELSTER AND GEITEL have sent us two papers dealing with their investigations on the nature of Becquerel rays. The experiments appear to negative the view that the source of energy of these rays is to be attributed to other radiations falling on the uranium salts which emit them, and Sir William Crookes' hypothesis that the energy is perhaps derived from the air, seems rendered doubtful by experiments made with uranium salts *in vacuo*. The authors confirm the discovery by M. and Mme. Curie of certain substances derivable from the uranium pitch of Joachimsthal, in Bohemia, possessing the property of emitting these rays in a high degree.

A SIMPLE verification of the principle of Archimedes for gases is described by M. P. Métral in the *Journal de Physique* for April. Two flasks, each of 1 litre capacity, are suspended from the scale pan of a balance. On placing the lower one in a vessel filled with carbon dioxide, the equilibrium is destroyed, but is restored again on filling the upper one with the same gas. To verify the principle for gases lighter than air, the two equal vessels are attached neck downwards by clamps to a horizontal beam suspended from the scale pan of a balance. On lowering an inverted jar of hydrogen over one vessel, equilibrium is broken, but is restored by filling the second vessel with hydrogen.

THE energy of Röntgen rays has been investigated by the Rev. Alexander Moffat by measuring the luminous energy given out by a fluorescent screen when exposed to the rays. This energy is of course very small, but it must be remembered that it only represents 4 per cent. of the energy impinging upon the screen, and also that the interval between two successive X-ray discharges is about 1000 times the period of time covered by the discharge itself. Allowing for these facts, it appears that if the Röntgen rays were continuous instead of intermittent, they would exert an effect 500 times greater than sunlight when falling perpendicularly upon a surface.

COHERERS made of platinum or gold filings do not "decohere" on shaking them up after the electric waves have ceased. The more oxidisable metals do. But as M. A. Blondel pointed out at a recent meeting of the Société Française de Physique, the greatest sensitiveness is attained when the metal is only moderately oxidisable, and good results are obtained with alloys of silver and copper artificially oxidised to a degree which can be easily recognised by the change of tint.

AN interesting and timely paper on milk as a food article appears in *Isis*. It is written by Dr. Schlossmann, and deals with the composition and properties of human and animal milk, and with the means for ensuring a proper supply of what is, with bread, the cheapest and most indispensable of food-stuffs. The adulteration of milk by water may be detected by the presence of nitric acid, which is never contained in undiluted milk. The number of dairies containing only healthy milch cows is very small indeed, but most of the danger may be averted by heating the milk to near boiling point, or by freezing it. One firm near Dresden adds quantities of milk ice to every consignment to keep it cool.

A NEW family of Palæozoic corals is introduced under the name *Moniloporidae*, by Mr. Amadeus W. Grabau (*Proc. Boston Soc. Nat. Hist*, April 1899). In this new family it is proposed to include the genera *Monilipora* and *Ceratopora*, forms found in Devonian and Lower Carboniferous strata. The genus *Monilipora* was established twenty years ago by the late Prof. Nicholson and Mr. R. Etheridge, jun. *Ceratopora* is now described by Mr. Grabau; it appears earlier in time than the other genus, and is less specialised in structure.

MR. LAWRENCE M. LAMBE publishes a series of notes on Canadian Palæozoic corals (*Ottawa Naturalist*, February and March 1899). He calls attention to certain structural details which had previously been overlooked or misinterpreted, and he describes one new species of *Lithostrotion*.

WE have just received vol. iv., No. 3, of "Indian Museum Notes," containing, *inter alia*, an article by Mr. F. Finn, the Deputy-Superintendent of the Museum, calling attention to the abundance of small green *Homoptera* (locally known as "green bugs") in India, and suggesting that they might be imported into England as food for cage-birds. There seems, however, to be some difference of opinion among the bird-fanciers who have experimented with them as to their value; but this may be due to their being more relished by some kind of birds than by others.

*Bulletin* No. 19 (new series), U.S. Department of Entomology, "Some insects injurious to garden and orchard crops, prepared under the direction of the Entomologist, by F. H. Chittenden, Assistant Entomologist," relates chiefly to *Coleoptera* (flea-beetles, chafers, bark-beetles, ladybirds, &c.), *Homoptera*, and *Lepidoptera*. Special attention is called to the squash ladybird (*Epilachna borealis*, Fab.) and the squash bugs (*Anasa tristis*, De Geer, and *A. armigera*, Say), and to the recently introduced moth (*Hellula undalis*, Fab.), a South European species, which has lately been committing serious ravages on cabbage, turnip, and other cruciferous plants in the neighbourhood of Augusta, Georgia.

A DESCRIPTIVE list of recent large scale maps, including both surveys and compilations, together with a list of some large atlases, has been prepared in the Intelligence Division of the War Office by Mr. Alexander Knox, Map Curator, and can be obtained from Messrs. Eyre and Spottiswoode. The volume forms a supplement to "Notes on the Government Surveys of the Principal Countries of the World."

A GLANCE through the new edition of the catalogue of physiological instruments manufactured by the Cambridge Scientific Instrument Company shows the importance of a knowledge of physics to physiologists and biologists, for without an acquaintance with physical principles it would be impossible to design or use many of the instruments described. Special attention may be called to the completeness of the list as regards recording drums and motors, apparatus for blood analysis, and anthropometric apparatus.

SEVERAL important papers appear in volume x. of the *Bulletin* of the American Museum of Natural History, just received from New York. Among the subjects dealt with are: Mexican birds; native tribes of Mexico; new mammals from Western Mexico and Lower California; complete skeletons of *Teleoceras fossiger* and *Coryphodon radians*, with notes upon the locomotion of these animals; extinct Camelidæ of North America and some associated forms; evolution of the amblypoda, revision of the species of Euchloë inhabiting America; the Chickarees, or North American red squirrels; vertebrate fauna of the Hudson Highlands; and the Bombycine Moths, found within fifty miles of New York City.

A THIRD edition, revised and enlarged, of Prof. J. Arthur Thomson's "Outlines ot Zoology" has been published by Mr. Young J. Pentland, Edinburgh. The volume, which contains more than eight hundred pages and 332 illustrations, is an inspiring text-book which students of zoology may use in the lecture-room, museum, and laboratory.—The seventh edition of "A Treatise on Practical Chemistry and Qualitative Analysis," by Prof. Frank Clowes, has been published by Messrs. J. and A. Churchill. The new edition of this successful volume has undergone a thorough revision, and some additions have been made. The organic portion of the book will now meet the needs of many medical students.—Messrs. A. and C. Black have published a second edition of Mr. C. M. Aikman's instructive little book on "Milk: its Nature and Composition." The volume provides students of agricultural science with a capital manual on the chemistry and bacteriology of milk, butter, and cheese.

MESSRS. WILLIAMS AND NORGATE's latest *Book Circular* (Scientific Series, No. 71, May) contains a number of useful descriptive notes on recent and forthcoming scientific books, as well as the usual particulars. Among the announcements, we notice the following:—A new monthly periodical devoted to biological sciences is announced from Italy. The title will be "Revista di Scienze Biologiche," and it will be edited by Enrico Morselli.—The third edition of Beilstein's "Handbuch der organischen Chemie" is now fast approaching its completion, and the final part of the fourth volume will probably be published in the course of the coming summer. The first volume, consisting of 1586 pages, was published in 1893; the second volume, of 2211 pages, in 1896; and the third, of 1020 pages, in 1897.—The new edition of Richter's "Lexikon der Kohlenstoffverbrudungen," which is at present in the press, will contain over 60,000 formulæ. The whole of the 56,000 formulæ which appear in Beilstein's Handbook will be indexed in the work, so that reference from it to Beilstein will be easy. —"Chimie végétale et agricole" is the title of a work by M. Berthelot which is in the press, and will be issued very shortly. It will be in four volumes.—The first volume of a fourth revised and enlarged edition of Dr. G. Lunge's "Chemisch-Technische Untersuchungsmethoden" is in the press, and will be published very shortly. The work will be complete in three volumes.—"Die Einrichtungen zur Erzeugung von Röntgenstrahlen und ihr Gebrauch" is the title of a work by Dr. B. Donatti which is in the press, and will be issued very shortly.—Towards the end of this month, the fourth and final volume of Prof. P. Duhem's "Traité élémentaire de mécanique chimique fondée sur la Thermodynamique" will be issued. The following is a list of its contents: "Les melanges doubles. Statique chimique générale des systèmes hetérogènes." The volume will also contain a complete index.

THE additions to the Zoological Society's Gardens during the past week include two Green Monkeys (*Cercopithecus callitrichus*, ♂ ♀) from West Africa, presented respectively by Mr. J. B. Robinson and Mr. H. Gifford; a Yellow-whiskered Lemur (*Lemur xanthomystax*, ♂) from Madagascar, presented by Mr. C. B. Ayerst and Miss Mary F. Ayerst; a Common Ducker (*Cephalophus grimmi*, ♂), a Banded Ichneumon (*Crossarchus fasciatus*) from South Africa, presented by Mr. W. Champion; a Cinereous Vulture (*Vultur monachus*), South European, presented by H.G. the Duchess of Marlborough; a Black Kite (*Milvus migrans*), European, presented by Mr. G. H. Walker; a Chilian Sea Eagle (*Geranoaetus melanoleucus*), captured off Cape Horn, presented by Captain Bate; six Derbian Zonures (*Zonurus giganteus*) from South Africa, presented by Mr. W. L. Sclater; two Common Snakes (*Tropidonotus natrix*) British, presented by Mr. E. Haig; a Chimpanzee (*Anthropopithecus troglodytes*, ♀) from West Africa, deposited.

## *OUR ASTRONOMICAL COLUMN.*

NEW STAR IN SAGITTARIUS.—The *Astrophysical Journal* for April 1899 (vol. ix.) contains a reproduction of a photograph of the spectrum of this star taken at Harvard College Observatory, together with a picture of a chart plate showing the position of the star on April 29, 1898, when its magnitude was 8·4.

The photograph of the spectrum shows the changes in the spectrum by a comparison of its appearance on April 19 and April 21, 1898. The first shows $H\beta$, $H\gamma$, $H\delta$, $H\epsilon$, $H\zeta$, $H\eta$, and possibly $H\theta$, as bright lines. A broad band at $\lambda$ 4643 is also bright, with several other *narrow* bright bands. These are probably coincident with corresponding lines in spectrum of Nova Aurigæ. The plate taken on the later date shows several important changes, chiefly the appearance of a *narrow bright* line at $\lambda$ 5005, possibly coinciding with the chief nebular line at $\lambda$ 5007.

COMET 1899 *a* (SWIFT).—

*Ephemeris for 12h. Berlin Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ | Br. |
|---|---|---|---|
| May 25 | 20 48 31 | +54 41·8 | 1·77 |
| 26 | 20 26 33 | 55 47·5 | |
| 27 | 20 3 7 | 56 38·4 | 1·71 |
| 28 | 19 38 21 | 57 11·4 | |
| 29 | 19 12 56 | 57 26 1 | 1·61 |
| 30 | 18 47 26 | 57 20·2 | |
| 31 | 18 22 26 | 56 55·6 | 1·49 |
| June 1 | 17 58 35 | +56 13·1 | |

The comet is now moving very rapidly in R.A., and becoming more favourably situated for observation. During the week it passes in a north-westerly direction through Cygnus into Draco. On the 25th it will be about 10° due north of $\alpha$ Cygni, and on June 1 4° north of $\gamma$ Draconis. It reaches its maximum northern declination on the 29th. Although its brightness has been steadily declining, it is still easily visible to the unaided eye when its position has been ascertained.

## *THE REGISTRATION OF OPTICIANS.*

OBSERVERS of the undercurrents of scientific progress in this country cannot have failed to note during the past twelve months a very remarkable movement at work amongst the opticians, especially amongst the younger men in the optical trades. An intelligent scientific study of the principles of optics has hitherto never been required of the optician, who from the first day of his apprenticeship might grow up in the business entirely untrained in everything save the mere buying and sell-

ing of optical goods. All this is rapidly changing, as indeed was to be desired. Half a century ago, the qualification for practising as a surgeon was practically a mere serving of indentures, while the trade of druggist might be practised by one who had never had any instruction in even the elements of chemistry. There was no organisation to examine the candidates, or to certify them if qualified; there was little stimulus to study. Hence, in the absence of any controlling body, the young men growing up in the optical trades have had little inducement to acquaint themselves with even the elements of the science on which their industry is based. Even those who might be studiously inclined found little to encourage them; for, strange to say, the existing text-books of optics are of little or no use to such. They are written mostly from a different standpoint, to enable University candidates to pass academical examinations, and fail to deal with many of the problems that present themselves to the practical optician. Further, great examining bodies, such as the Science and Art Department and the City and Guilds of London Institute, have never formulated any examinations in optics or optical instrument making.

The present salutary movement has originated quite outside academic circles, having arisen in the ancient London guild called the Spectacle-makers' Company, which, like so many of the old London guilds—the Clothworkers', the Leathersellers', the Carpenters', and the Plumbers' Company—has most laudably devoted of its funds to the promotion of the industry from which it takes its name. The Spectacle-makers' Company is not one of the twelve great Companies holding landed property nor possessed of great wealth. Relatively to the great City Companies, such as the Mercers, Goldsmiths, Fishmongers, Drapers, it is poor. But it has shown much energy and enterprise in organising the certification of opticians. Briefly, what the Spectacle-makers' Company has done is this: it holds at least twice a year examinations in optics, open only to those who have entered the optical trades; and on those who have thus shown a real acquaintance both with the theory and the practice of their trade, it confers a diploma or certificate, and registers them as qualified in optics. It further admits them to the freedom of the guild. The stimulus thus afforded to those in the optical industry in this country has been undeniably very great. Optical classes have been eagerly sought in London, and have also been held in many provincial towns, and a widespread demand for optical literature has sprung up.

The scope of this movement may best be understood by a reference to the official syllabus put forward by the Spectacle-makers' Company. It states that when the Company was granted a Royal Charter in 1629, spectacles were practically the only optical instruments dealt in; but with the progress of science as other instruments were invented, the spectacle-maker became a general optician. With the division of labour which arose, the trade became divided. It is the object of the Spectacle-makers' Company to re-associate with the guild all who possess the necessary technical ability. A theoretical and practical examination must be passed by those candidates who are recommended as eligible by two established members of the craft. The full examination comprises arithmetic, algebra, trigonometry, elementary heat and light, as well as general optics, optical instruments, and spectacles, practical tests in optical work, in visual optics so far as instruments are concerned, and in matters connected with one of the following instruments: the camera, the microscope, and the sextant, at the choice of the candidate. The part of the examination relating to visual optics deals with the general anatomy of the human eye; the course of light passing through the eye and modified by lenses, cylinders, and prisms. It deals also with the simple "errors of refraction," otherwise called hypermetropia, myopia, presbyopia, and astigmatism. It requires a knowledge of trial lenses, test types, astigmatic charts, and the optometer, &c. In the practical tests, candidates are required to execute measurements of focal length, and to verify cylindrical and prismatic lenses; to use the spherometer; to determine the axis of a cylinder and the deviation of a prism; to neutralise simple and combined lenses; to transpose lens combinations; and to centre and adjust lenses and frames, &c. It has been the practice, at the inauguration of similar schemes, to make some exceptions by admitting without examination those men who had long been in practice. But the Committee of the Spectacle-makers' Company decided that even such should be examined; it conceded, however, that down to July 1, 1899, all who had spent seven years in the optical business might be accepted, provided they succeeded in passing that part of the examination which relates specially to spectacles.

The Optical Committee has itself organised classes for optical instruction, and has carefully limited the training so as not to trench on the province of the ophthalmic surgeon. As examples of this case, it may be stated that students are specially instructed that they are not to treat disease, or any case of myopia above seven *dioptres*, but refer such to an ophthalmic surgeon; and so also the cases of children whose punctum proximum is beyond 10 centimetres, or any persons who cannot, when corrected for a simple error of refraction, see 20/20 print.

The first examinations under this scheme were held in November 1898, and they were followed by a second series in March 1899. The examiners selected by the Optical Committee of the Company were Prof. Silvanus Thompson, F.R.S., Dr. Lindsay Johnson, and Mr. G. Paxton of the well-known firm of Curry and Paxton, the latter being assisted in the practical examination by Messrs. A. A. Wood and W. A. Dixey. At each of these examinations over a hundred candidates presented themselves. The examinations were strictly on the lines indicated, no questions being set as to the diseases of the eye, or in retinoscopy, or on matters outside the province of optics proper.

At the outset, it was necessary to guard against any misapprehension as to the scope and nature of the examination scheme, which might have led to difficulties between opticians and ophthalmic surgeons, such as those which in time past have arisen between pharmacists and qualified medical practitioners. Very wisely, it was decided that the examination should be confined to optical matters, and should not treat of disease, nor even of the eye at all save as an optical instrument. The examination is to test candidates solely in matters of optics, so as in no way to interfere in things that lie within the exclusive province of the ophthalmic surgeon. In pursuance of this policy, the application of the ophthalmoscope to the eye, which is a matter for the ophthalmic surgeon, is excluded from the subjects of the examination. On the other hand, the principle of construction of the ophthalmoscope, which is a matter within the province of the optical instrument maker, is included. Recognising that the use of drugs, such as cocaine and homatropine in retinoscopy, is purely a matter for the ophthalmic surgeon, the Spectacle-makers' Company not only excludes from its syllabus of examinations all optical tests implying or requiring their use, but it sternly discourages the idea that an optician should go out of his sphere to meddle with such matters. Nay, further, it requires, amongst the conditions upon which its diploma is held, that the holder shall sign a declaration that he will not use any drugs for the purpose of dilating the pupil.

It is believed that the firm stand thus made officially by the Spectacle-makers' Company will have a beneficial effect in stamping out a practice which—particularly in certain provincial centres—had been growing up of opticians, devoid of any medical qualification, administering drugs such as homatropine, and pretending to make retinoscopic tests that ought to be left to the ophthalmic surgeon. In yet one other direction the certification and registration of opticians will, as it becomes general, promote the interests of the public. There are, unfortunately, in many towns advertising opticians absolutely unqualified scientifically who deceive the public by pretending to impossibilities such as the curing of cataract without operation, and the like. The Medical Acts are unfortunately powerless to reach these; and hitherto the public has had no means of distinguishing between them and the really qualified opticians, since until now there has been no organisation to register the properly-qualified optician. But as the certification of really qualified opticians becomes general, it will be possible to detect and eliminate the quack, whilst the qualified optician will be deterred, at the risk of being disbarred, from issuing advertisements that would mislead the public. Already, even at this early stage, the advantages of organisation have become apparent, the Committee of the Company having already several times been called upon to intervene to insist on the withdrawal of advertisements which might be thought misleading to the public or unfair to other opticians.

The impulse to optical studies has been undeniable, and is certain to spread. The demand of the younger men in the optical industry for optical teaching that will be of service to them will certainly modify the abstract and jejeune courses of scholastic optics offered to them in some of the provincial University colleges, where the optics of the workshop, and even

the methods of optical testing in use in the industry, are practically unknown, and science as well as the public will be gainers by the movement. A debt of gratitude is owing to the Court of the Spectacle-makers' Company, and to its Master (Mr. W. E Thornthwaite) for their efforts. The Company has lately received notable accessions of strength in having admitted to its freedom several of the highest names in science, including the Astronomer Royal, Captain W. de W. Abney, Sir William Crookes, and, last but not least, Lord Kelvin.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The seventh "Robert Boyle" lecture of the Junior Scientific Club will be delivered by Prof. J. G. McKendrick, F.R.S, in the large lecture theatre at the University Museum, on Tuesday, June 6, at 8.30. The subject will be "The physiological perception of musical tone."

The 201st meeting of the Junior Scientific Club was held on Wednesday, May 17. After private business, Prof. E. B. Tylor, F.R.S., read a paper on the survival of the palæolithic condition of man in the South Pacific region. Mr. R. D. MacGregor (Exeter) also read a paper on Indian butterflies

CAMBRIDGE.—The subject of the Rede Lecture, to be delivered by Prof. Cornu on June 1, is "The Wave Theory of Light: its Influence on Modern Physics."

Admission to the ceremonies in the Senate House, in connection with the jubilee of Sir G. G. Stokes on June 2, will be by ticket. Applications must be made through members of the Senate not later than May 26.

The General Board have proposed the detailed regulations for the Board of Agricultural Studies in connection with the new Department of Agriculture. County and Borough Councils who contribute annual grants to the funds of the Department are to nominate members of the Board.

Honorary degrees are on June 2 to be conferred on Profs. Cornu and Darboux of Paris, Kohlrausch of Berlin, Michelson of Chicago, Mittag-Leffler of Stockholm, Quincke of Heidelberg, and Voigt of Göttingen.

Prof. Newton, who has recently been somewhat out of health, is to depute his lectures in zoology during the ensuing academical year to Mr. W. Bateson, F.R.S., of St. John's College.

Mr. Neville, F.R.S., of Sidney, has been appointed an elector to the chair of Chemistry; and Mr. Larmor, F.R.S., of St. John's, an elector to the Jacksonian professorship, in place or the late Mr. P. T. Main.

THE endowment of a quarter of a million for the University of Birmingham has been secured. At a meeting of the canvassing committee on Thursday last, it was announced that since the previous meeting 24,000*l.* had been promised, and that this, added to the sum previously promised, including the 50,000*l.* from Mr Carnegie and the 37,500*l.* from the anonymous donor, brought the total up to 254,580*l.*, or 4580*l.* in excess of the amount originally fixed upon. The anonymous donor, recognising that the endowment of 250,000*l.*, although sufficient for a starting point, must soon be largely augmented, has offered, if the fund is raised to 300,000*l.* by the end of June, to contribute the last 12,500*l.* The committee have now to find 33,000*l.* to secure the additional 12,500*l.* from the anonymous donor. If this is obtained, it will make 50,000*l.* altogether subscribed by Mr. Chamberlain's friend.

THE following additional endowments and gifts to educational institutions in the United States are recorded in *Science*:—An Appropriation Bill recently passed by the Illinois Legislature gives to the University of Illinois about 600,000 dollars. The Wisconsin Legislature has appropriated for the University of Wisconsin 151,000 dollars, of which 100,000 dollars is for an engineering building. The Colorado Legislature, besides passing a Bill giving its State University an income of one-fifth of a mill on each dollar of assessed valuation, has made grants amounting to about 110,000 dollars. In Nebraska, the State University has been given a one-mill tax, which will, it is estimated, yield about 168,000 dollars yearly.—Columbia University has recently received a gift of 10,000 dollars, to be known as the Dyckman Fund for the encouragement of biological research, the interest of which will be granted to post-graduate students.

THE subjoined table, showing the ratio of the teaching staff to the number of students in ten of the largest universities of the United States, is printed in *Science*. The first column gives the number of persons composing the faculty, including instructors of all grades; the second gives the total number of students enrolled in the institution; the third, the proportion students to teachers.

| | Faculty. | Students. | Ratio |
|---|---|---|---|
| Johns Hopkins | 123 | 641 | 5·2 |
| Cornell | 328 | 2038 | 6·2 |
| Columbia | 303 | 2185 | 7·2 |
| California | 286 | 2391 | 8·3 |
| North-western | 222 | 2019 | 9·1 |
| Harvard | 411 | 3901 | 9·4 |
| Yale | 255 | 2500 | 9·7 |
| Chicago | 212 | 2307 | 10·9 |
| Pennsylvania | 258 | 2834 | 10 9 |
| Michigan | 222 | 3192 | 14·4 |
| Total | 2620 | 24,008 | 9·1 |

## SCIENTIFIC SERIALS.

*American Journal of Mathematics*, vol. xxi. No. 2, April.—On systems of multiform functions belonging to a group of linear substitutions with uniform coefficients, by E. J. Wilczynski In this memoir, the author attempts to prove the existence of certain general functions, studied herein, he believes, for the first time. The existence of a large and important class of these functions is demonstrated by an indirect method, which consists essentially in generalising the hypergeometric functions in a proper manner. The work is connected in a way with the researches of Fuchs, Schwarz and Neumann (on Riemann's theory of Abelian functions, and of Klein (*Math. Ann.*, Bd. 41). Oskar Bolza states that his principal object, in his paper on the partial differential equations for the hyperelliptic $\theta$ and $\sigma$ functions, is to replace part of Wiltheiss's work (*Crelle*, Bd. 99, and *Math. Ann.*, Bd., 29, 31 and 33) by simpler and more direct proofs.—E. B. Van Vleck contributes an article on certain differential equations of the second order allied to Hermite's equation. The treatment is thorough, and the work is accompanied with numerous diagrams.—Note on differential invariants of a system of $m$ points by projective transformation, by E. O. Lovett, shows that to generalise a theorem of Henry Smith's relative to tangent curves (*cf.* on the focal properties of homographic figures (*Proc. London Math. Soc.*, vol. ii.) and the theorem relative to parallel curves, it is only necessary to substitute "surface" for "curve" and "measure of curvature" for "radius of curvature." A second (short) paper by Bolza is entitled "Proof of Brioschi's recursion formula for the expansion of the even $\sigma$ functions of two variables." The author believes that no proof of these theorems has hitherto been published. Brioschi merely stated them in a note (*Goettingen Nachrichten*, 1890, p. 237).—E. Jahnke supplies a two-page note to Prof. Craig's memoir, "Displacements depending on one, two and three parameters in a space of four dimensions."—There is an interesting prefatory notice, from which we learn that Prof. Craig, after seventeen years' connection with the editorial work of the Journal, is succeeded by Prof. Simon Newcomb, who writes this exceedingly modest notice.

*Symons's Monthly Meteorological Magazine*, May.—Ozone, by D A. van Bastelaer. Since 1886, the author has persistently registered the amount of ozone and submitted reports to the Royal Society of Public Health of Belgium, and has also published five-day means throughout the year, with the idea of their being used in connection with the death-rate. Although at individual stations the amount of discoloration varies greatly from day to day, the means remain very steady both for months and for years. Some places, especially Flanders and the neighbourhood of the Ardennes, have constantly much higher means than others. Mr. Symons remarks that it has sometimes been objected that the discoloration of ozone papers is not solely due to the presence of ozone, so that the subject is generally neglected, but there is probably no equally simple and trustworthy indication of the freshness of the atmosphere, and he therefore urges that such records should be kept.

## SOCIETIES AND ACADEMIES.

### LONDON.

**Royal Society**, April 20.—Some further Remarks on Red-water or Texas Fever. By Alexander Edington, M.B., F.R.S.E., Director of the Bacteriological Institute, Cape Colony. Communicated by Dr. Gill, F.R.S.

Since my communication[1] to the Royal Society of London, by Prof. Thomas R. Frazer, I have been able to obtain valuable additional evidence as to the communicability of the disease by the use of blood derived from animals which have been either recovered from the sickness for a very considerable time, or which have been inoculated many months previously to the date on which their blood has been used.

On December 8, 1898, I withdrew some blood from animal No. 18, which has been continuously under observation since it was inoculated on December 22, 1897. After defibrinating the blood, 20 c.c. was used to inoculate a young ox (No. 54) by intravenous injection. On the following day, a sharp rise of temperature occurred, which reached to 106°·6 F. On the following morning it was observed to have fallen to 99°·8 F. Three days later the temperature was again over 104° F., but fell previous to the next morning. From this time onward an erratic course of temperature was observed, and on the twenty-fifth day, subsequent to inoculation, it was seen to be ill; refused food, but had no definite symptoms of "red-water." Three days later it died. The blood on examination was seen to contain the spherical forms of the parasite.

On post-mortem examination, the bladder and urine were quite normal. The liver was not enlarged, but was somewhat discoloured in patches, and the biliary ducts were distended with bile. The bile was much altered, being stringy and of a greenish-yellow colour. The spleen was normal in size and consistence. The kidneys were enlarged, and the pelves were filled up by a yellowish gelatinous exudation. The cortex was somewhat congested, but there was no evidence of any true inflammatory change. The general muscles were pale in colour, and there was slight evidence of jaundice. This experiment serves to show that an animal which has been inoculated with infected blood, while it may not develop much illness as a result of it, is really infected and, moreover, its blood, if drawn as late as a year subsequently, is yet so infective that an intravenous injection of it, into susceptible animals, will certainly infect, and may even kill, although after a somewhat extended period of time.

Very important corroboration of this is furnished by the experience of inoculation for red-water, which has lately been adopted in the Cape Colony. Four animals which were immune to red-water (three by reason of having had the disease and recovered, and one by being born and reared on permanently infected veld) were sent from Fort Beaufort to Queenstown to be used by the veterinary surgeon there for inoculation purposes. The animals to be used for inoculation had been "fortified," *i.e.* re-inoculated with virulent blood, seven weeks previously.

Twenty animals were inoculated with defibrinated blood from one animal, the doses used being 10 to 20 c.c., according to age. All had a febrile reaction and some slight symptoms of the sickness, but easily recovered. From one of the other of the four animals blood was taken and used to inoculate seven head, giving doses of 10 to 15 c.c. These also all had a reaction, but made good recovery.

On November 1, the four animals were re-inoculated with virulent red-water blood, and in each case 5 c.c. was injected intravenously and 10 c.c. subcutaneously. Twenty-nine days later they were bled. With this blood two lots of cattle were inoculated.

One lot consisted of 107 animals which had not ever been exposed to red-water infection. The doses used were increased beyond those which I had recommended, namely, 10 to 25 c.c. were used, according to age. Of these animals no less than seventeen died of characteristic red-water. The remainder made a good recovery.

The second lot consisted of fifty-three head of cattle, all of which with one exception (an imported animal) had been born and reared on red-water veld. The imported animal was the only one which showed any signs of reaction, but it made a good recovery.

This experience has sufficed to show that it is not always safe to exceed the doses which I have recommended, unless the animals which have been used for withdrawing blood have been untouched for at least a considerable number of months.

I have been able, with the co-operation of several farmers, to carry out experiments by which inoculated cattle have been fully exposed to infection at later dates. In May 1898, I inoculated ten head of old cattle with blood from an animal which had been inoculated, six months previously, with virulent blood. These cattle were immediately removed from the Institute, and later sent to an infected area in company with ten head of young animals which were uninoculated, but, as is commonly known in this Colony, are not so liable to death from this disease as are older animals. Of the young stock all have been infected by exposure in the veld, and three have died. Of the older, more susceptible, animals not one has shown the slightest signs of illness, and the cows have given birth to healthy calves.

Mr. J. H. Webber had twenty-eight head of Fish River cattle inoculated on November 7, 1898, and subsequently had them removed to his farm, which is well known to be one of the worst infested areas in the eastern province. Previous experience has shown that if clean cattle are placed there they become very quickly affected with the disease. On December 5, one died from gall-sickness, but, with this exception, all have done very well, and are at this date in perfect health.

This method of inoculation has proved so satisfactory to the farmers themselves that it is being very generally adopted, and the farmers have petitioned the Government to arrange for an inoculating station being placed at Graham's Town, so that clean cattle coming from clean Karroo areas for transmission to the coast may be inoculated previous to entering the infested belt.

April 27.—"Data for the Problem of Evolution in Man. I. A First Study of the Variability and Correlation of the Hand." By Miss M. A. Whiteley, B.Sc., and Karl Pearson, F.R.S.

In a more purely theoretical discussion of the influence of natural selection on the variability and correlation of species, which one of the present writers hopes shortly to publish, a number of theorems are proved which it is desirable to illustrate numerically. But the quantitative measures of the variability and correlation hitherto published are comparatively few in number, especially when, as in the present case, we desire to have their values for a number of local races of the same species. When we have once realised that neither variability nor correlation are constant for local races but are modified in a determinate manner by natural selection and, perhaps, by use, and further that their differences are the key to the problem of how selection has differentiated local races, then the importance of putting on record all the quantitative measures we can possibly ascertain of variability and correlation becomes apparent.

This first study deals only with one character of the hand in one sex and one race. A wider range of material on the skeleton of the hand in another local race is already being dealt with. But while the correlation of the anatomically simple parts of the hand is of very great importance, it does not follow that the complex members of the living hand may not be equally, or even more, significant when we have to deal with fitness for

[1] The conclusions arrived at in that communication (received June 6 1898) were as follows:—

1. The blood of animals, themselves healthy, from a red-water area is dangerous if inoculated into an animal which suffers coincidentally from another disease.

2. That the blood of animals suffering from mild or modified red-water may be safely used to inoculate a healthy animal *subcutaneously*, but is dangerous when injected into a vein.

3. That the subcutaneous inoculation of mild or modified red-water blood conveys a mild form of the disease, and since the blood of such an animal is virulent when injected into a vein in another animal, it is safely to be inferred that the animal suffering from the mild form becomes more or less immunised or "salted."

On these grounds, I would suggest a method of protective inoculation against red-water in the following manner. Having procured a healthy animal from a red-water area or one which is known to have been "salted," inoculate it by injecting 5 c.c. of red-water blood into the jugular vein and 5 c.c. subcutaneously. In cases where the operator is unable to attempt the vein inoculation, I would recommend the subcutaneous inoculation of 5 c.c. in four different sites.

Allow at least twenty-eight days to elapse, and if any degree of illness is recognised, the blood of this animal may be used, after being defibrinated, to inoculate healthy cattle. For such inoculation only 5 c.c. should be injected into small animals, and not more than 10 c.c. into larger.

Seeing, however, that the presence of other maladies renders such a proceeding unsafe, I would recommend that it should only be practised during the autumn or winter, when the veld diseases are, as a rule, in abeyance, and in no case when any epidemic disease is in the near neighbourhood.

the struggle for existence. So far as we have been able to ascertain, although much has been written as to the fitness of the hand for its tasks, no attempt has ever been made to ascertain quantitatively the degree of correlation of its parts.[1] Hence our first object was to get some idea of the correlation of the parts of the hand from an easily measured and in practice important part. Is the hand as highly correlated as the long bones, or as loosely correlated as the parts of the skull, or does it occupy some intermediate position like that of strength to stature? We accordingly selected as an easily measured but still important character the first joint of the fingers. The measurement therefore covers, besides the fleshy parts, the head of the metacarpal bone together with the proximal phalange. It is thus not anatomically simple, but it probably has much importance for the fitness of the hand, and is a measurement which with a little care can be made with considerable accuracy. Our measurements were taken with a small boxwood spanner graduated to 1/10 inch, and provided with a vernier, so that the readings could be nominally made to 1/100 inch. Both the hands of 551 women were measured.

*Relative Size of the Hands.*—We conclude that the first finger joints in the right hand are very sensibly larger than in the left. In every case there is a difference of about 0·02, and this is many times larger than the probable error of the difference, *i.e.* $\sqrt{2} \times 0{\cdot}003$ about.

We might, therefore, assert that the right hand is larger than the left. This conclusion is directly opposed to that of W. Pfitzner; he asserts that there is no quantitative difference between right and left for the simple anatomical parts of the hand skeleton. His own measurements, however, really do show such a sensible difference for the *first* phalange. All then we can say as yet is that the first joint and the first phalange are larger in the right than in the left hand of women. We prefer to state no more sweeping view at present as to other parts of the hand, however strong our private opinion may be.

*Variability of the Hand.*—If we were to judge by *absolute* variations the index and middle fingers of the right hand are less, the ring and little fingers more variable, than those of the left hand. But if we use the more reasonable coefficient of variation, we find that all the first joints for the left hand are more variable than the corresponding joints for the right hand, and this is precisely what we might expect if there be greater adaptation by selection, or by use of the right hand. The greater the selection, the less the variability.

In the left hand the relative order of variability (as measured by the coefficient of variation) is that of the relative size of the fingers; in the right hand this is slightly modified. It would appear that in the right hand the index finger is less variable than the middle finger. The general order of utility of the fingers would appear to be middle finger, index finger, ring finger, little finger, and this exactly agrees with the order of increasing variability in the left hand. The only doubt about this order appears in the relative efficiency and utility of the middle and index fingers, which have a different order of variability in the right hand.

As all our subjects belonged to the educated classes, it is just possible that the great use of the right hand index finger in writing has something to do with this diversity.

*Correlation of the First Finger Joints.*—The conclusions reached are: (1) The hand is a very highly correlated organ, far more highly correlated than the skull, and even somewhat more so than the long bones. We are accustomed to give man precedence in life on account of his brain power, and it might, perhaps, be thought that the brain case would be highly correlated in its parts. Yet what we find is that the skull is extremely individual, its correlations are low, and a man could be readily identified by head measurements, whereas hand measurements would be immensely less safe. In other words, the hand, so far as its dimensions go (we put aside markings), is far closer to a type than the skull.

(2) The parts of the left hand are distinctly more closely correlated than those of the right. The only exception is the correlation of right hand middle and little fingers, which is greater than that of left hand middle and index fingers: but the difference here is considerably less than the probable error of the difference, and the general rule appears to be quite certain. Now this is a most remarkable result; but, again, how is it to be interpreted? Is it a result of selection or a use effect? For the same organ it is a rule that the greater the selection the less the variability and the less the correlation. Exceptions there can be, which will be discussed elsewhere, but this appears to be the general rule. Is the less variability and correlation of the right hand a result of greater selection, or is it after all a result of use? If the latter, we see how hopeless it is to associate constancy of correlation, or even of regression coefficients, with the idea of local races. Indeed the further we enter into the quantitative side of the problem of evolution the more important appears the determination of the influence of growth and use on both variability and correlation. Why is the right hand less variable and less highly correlated than the left? Is the answer the same as to the question: Why is civilised man less variable and less highly correlated than civilised woman?

(3) The order of correlation of the first finger joints is identical for both hands. This order is as follows:—

(*a*) The external fingers have the least correlation and the little finger always less than the index.

(*b*) A finger has always more correlation with a second than with any other finger from which it is separated by the second.

(4) The correlation between corresponding members on both sides is discussed. It is found that again the extreme pairs show least correlation, and the pair of middle fingers higher correlation than the pair of ring fingers.

It is noted that the correlation between corresponding long bones (with the possible exception of that of the radii which is within the probable error of the value for the middle fingers) is greater than that between corresponding parts of the two hands.

The memoir indicates how important it is that the effect of use on both variation and correlation should be determined. It suggests that use may have differentiated in this manner the right from the left hand. But if it has affected variability and correlation here, how far can we look upon these quantities in local races as characteristic of the intensity of selection? The memoir concludes with numerical tables giving the results of the measurements made.

May 4.—"*Onygena equina* (Willd.): a Horn destroying Fungus." By H. Marshall Ward, D.Sc., F.R.S., Professor of Botany in the University of Cambridge.

The genus *Onygena* comprises half a dozen species of fungi, all very imperfectly known, remarkable for their growth on feathers, hair, horn, hoofs, &c., on which their sporocarps appear as drum-stick shaped bodies 5–10 mm. high. The author has recently investigated the life-history of the above species, growing on a cow's horn, and has not only verified what little was known as to its structure, but has been able to cultivate the fungus and trace its course of life, neither of which had been done before, and to supply some details of its action on the horn.

The principal new points concern the development of the sporophores, which arise as domed or club-shaped masses of hyphæ and stand up into the air covered with a glistening white powder. Closer investigation shows this to consist of a hitherto undiscovered form of spores—chlamydospores—developed at the free ends of the up-growing hyphæ. The details of their structure and development are fully described, and their spore nature proved by culture in hanging drops. The germination, growth into mycelia, and peculiar biology of these hitherto unknown spores were followed in detail, and in some cases new crops of chlamydospores obtained direct in the cultures.

The development of the peridium, asci, and ascospores were also followed in detail, and for the first time.

No one had hitherto been able to trace the germination of these ascospores—the only spores previously known in these fungi—and De Bary expressly stated his failure to do it. The author finds that they require digesting in gastric juice. By using artificial gastric juice, and employing glue and other products of hydrolysis of horn, the details of germination and growth into mycelia, capable of infecting horn, were traced step by step under the microscope and fully described.

The author also found that gastric digestion similarly promotes the germination of the chlamydospores, and in both cases has not only traced the germination step by step, but has made measurements of the growth of the mycelium, induced the formation of chlamydospores on the mycelium again, and by

[1] Here, as in other cases, both zoologists and anatomists have since the days of Cuvier, talked a good deal about correlation, but would even to-day be unable to reconstruct, with anything like *quantitative* accuracy, a skeleton from a long bone, a hand from a finger joint, or a skull from a fragment.

transferring vigorous young mycelia to thin shavings of horn has observed the infection of the latter.

It thus becomes evident that the spores of *Onygena* pass through the body of an animal in nature, and, as might be expected from this, extract of the animal's dung also affords a suitable food medium for the fungus. Probably the cattle lick the *Onygena* spores from their own or each other's hides, hoofs, horns, &c., and this may explain why the fungus is so rarely observed on the living animal: it is recorded from such in at least one case however.

Very little is known as to the constitution of horn, and some experiments have been made to try to answer the question—what changes the fungus brings about. The research has bearings on the question of the decomposition of hair, horn, feathers, hoofs, &c., used as manure in agriculture; and may be not without significance in throwing light on the destruction of cuticle, hair, &c., by parasitic fungi.

"The Thermal Expansion of Pure Nickel and Cobalt." By A. E. Tutton, B.Sc. Communicated by Prof. Tilden, D.Sc., F.R.S.

The author has carried out a series of re-determinations of the coefficients of thermal expansion of these two metals with the aid of the interference dilatometer described in a former communication to the Society (*Phil. Trans.*, A, vol. cxci. p. 313; *Roy. Soc. Proc.*, vol. lxiii. p. 208). Since the determinations made by Fizeau in the year 1869, a large amount of additional knowledge has been accumulated with reference to nickel and cobalt, including the discovery of the liquid nickel carbonyl, which places processes of purification in the hands of the chemist of a character so superior to the older methods, as to render it highly desirable that re-determinations of the physical constants of these interesting elements should be carried out with specimens of the metals thus purified. By the kindness of Prof. Tilden, who has prepared such specimens with infinite care for the purposes of the investigation of other physical and chemical characters, the author has been enabled to carry out determinations of the thermal expansion with rectangular blocks varying in thickness from 8 to 13 mm. The blocks were furnished with parallel and truly plane surfaces by the makers of the dilatometer, Messrs. Troughton and Simms. The range of temperature of the observations was from 6° to 121°.

The results of the determinations of the coefficients of linear expansion $\alpha$ are as follows:—

$$\alpha = a + 2bt.$$

For nickel ... $\alpha = 0{\cdot}000\ 012\ 48 + 0{\cdot}000\ 000\ 014\ 8t.$

For cobalt ... $\alpha = 0{\cdot}000\ 012\ 08 + 0{\cdot}000\ 000\ 012\ 8t.$

The coefficients of linear expansion $\alpha$ of pure nickel and cobalt thus exhibit a slight but real difference, the coefficient of nickel being distinctly greater than that of cobalt. This is true with respect to both the constant $a$, the coefficient for 0°, and the increment per degree, $2b$, of the general expression for the coefficient at any temperature $t$, $\alpha = a + 2bt$. The difference is consequently one which augments with the temperature; at 0° it amounts to 3·2 per cent., while at 120°, the upper limit of the temperatures of the observations, it attains 4·5 per cent. Similar rules apply naturally to the cubical coefficients. The metal possessing the slightly lower atomic weight, nickel, is thus found to expand to a greater extent than the metal, cobalt, which is endowed with the higher atomic weight.

"Impact with a Liquid Surface, studied by the aid of Instantaneous Photography. Paper II." By A. M. Worthington, M.A., F.R.S., and R. S. Cole, M.A.

This paper is a continuation of a paper under a similar title, published in the *Philosophical Transactions*, vol. clxxxix., 1897.

It was there shown that, between the splash of a rough and of a polished sphere falling the same distance into water, there is a remarkable difference from the first moment of contact. The causes of this difference are now investigated.

The configuration of the water surface below the general level, when a rough sphere enters, is first studied by instantaneous photography, and the origin is traced of the bubble that follows in the wake of the sphere and of the emergent jet which follows its disappearance. The depression or crater formed round the entering sphere is surprisingly deep. This cavity segments, the lower part following as a bubble in the wake of the sphere, while the upper part fills up by the influx of surrounding water, which gathers velocity as it converges towards the axis of the disturbance, and so produces the upward spirt of the jet.

The actual displacement of the liquid has been studied by letting the sphere descend between two vertical slowly ascending streams of minute bubbles liberated by electrolysis from two pointed electrodes.

The splash of a smooth sphere is traced by gradual transition into that of a rough one as the height of fall is increased. But the course of the disturbance is largely dependent on minute differences in the condition of the surface, and even on its temperature. It was further found that dropping a smooth sphere through a flame, under certain conditions, invariably alters entirely the course of the splash. This action of the flame is proved to be no action of electrical discharge, and reasons are given for attributing it to the burning off of fine dust which has collected on the surface during the fall.

The influence of dust was proved by dusting one side only of a polished sphere, a proceeding which always results in completely changing the character of the splash on the dusted side.

A satisfactory general explanation of all the phenomera is found in the view that with a smooth sphere, cohesion is operative in guiding the advancing edge of the liquid sheath which rises over and closely envelops the sphere. If the surface is not rigid (*e.g.* is dusty), or is rough, then the momentum of the sheath carries it, once for all, away from the surface of the sphere, and the subsequent motion is quite different. The persistence of the remarkable radial ribs or flutings observable in the film that ensheaths a smooth entering sphere is completely explained by the assumption of a viscous drag spreading from the surface of the sphere outwards, and these flutings are always absent from any part of the sheath that has left the sphere. Their presence is thus an indication that there is no finite slip at the solid surface.

Experiments *in vacuo* show that the influence of the air is quite secondary. The similarity of the splash in a liquid with that due to the impact of a steel projectile on an armour-plate is referred to as requiring further investigation.

"The External Features in the Development of *Lepidosiren paradoxa*, Fitz." By J. Graham Kerr. Communicated by A. Sedgwick, F.R.S.

The eggs, averaging between 6·5 and 7 mm. in diameter, are deposited in a burrow at the bottom of the swamp. They are of a pale salmon colour without a trace of dark pigment. Segmentation closely resembles that of *Amia*. Gastrulation begins with the appearance of a row of depressions, or a continuous groove, running round about one-third of the length of the boundary between large and small cells. As this deepens to form the archenteron it shortens up, and the ultimately formed crescentic blastopore is only about a quarter of the length of the original groove. The medullary folds are low and inconspicuous, and meet behind the blastopore, which later becomes the anus. The over-arching of the medullary folds towards one another takes place to a certain extent, but the canal so covered in soon disappears, and the central canal of the nervous system is a secondary excavation. There is no trace externally of a *protostomal* seam running along the floor of the medullary groove. A somewhat tadpole-like larva hatches out, which assumes a remarkably amphibian appearance. This develops on each side four large pinnate external or somatic gills, upon branchial arches I, II, III, and IV. A large cement organ is also present, which during its early stages has the crescentic or U-shape so frequent in the embryos of Anura. Both cement organ and somatic gills are purely larval structures. During the atrophy of the latter they come by differential growth to be situated just over the fore limb, giving a similar condition to that well known in *Protopterus* of a larger growth.

The paper concludes with remarks of a general character upon the phenomena described.

**Linnean Society**, April 20.—Dr. A. Günther, F.R.S., President, in the chair.—Mr. George Murray, F.R.S., exhibited several slides of new *Peridiniaceae*, and gave some account of the method of collection by pumping, which had been found most efficacious with these organisms.—Mr. J. B. Carruthers communicated some observations on the localised nature of the parent characters in hybrid fruits of *Theobroma cacao*, on which some criticism was offered by the Rev. G. Henslow.—Mr. H. H. W. Pearson read a paper on the botany of the Ceylon "patanas," large savannahs in the forests at the same subtropical levels, and with the same climate, though not peculiar to Ceylon. These "patanas" appear to maintain their limits for long periods; but whether they thus exist on account of the

burning of the grass in autumn, or by reason of some peculiarity in the climate, or exposure, is a question on which some difference of opinion has been expressed. A discussion followed, from which it appeared that the author of the paper had not definitely settled the problem.—The Rev. O. Pickard Cambridge, F.R.S., communicated a new list of British and Irish spiders. After reviewing the existing literature on the subject, and the materials which had come to hand since 1881 for a new and revised list of species, the author pointed out that the present paper was not intended merely for the use of authors or collectors interested in local faunas, but to give (with references to primary authorities) the spiders at present known to belong to Great Britain and Ireland, leaving the question of their distribution, abundance, or scarcity to be dealt with at some future time, when the present scanty number of spider-collectors might have increased. At present, large areas of varied natural characters, in some cases whole counties, and many maritime districts, were entirely unexplored, so far as the Arachnology is concerned.—Prof. R. J. Anderson communicated a paper entitled "Imitation as a source of anomalies." Commenting upon the statement made by Profs. Krause and Testut that muscular anomalies are rare in the lower animals, whilst in man they are very common, the author considered it remarkable that no single instance had been authenticated in recent times of a mammal fairly attempting to utter a human voice-sound, although this did not apply to birds. He suggested that in the attempt to imitate, the mental act, or volition, if sustained, might favour a change of a moderate nature, and that such a change might be either progressive or retrogressive.

**Geological Society**, April 26.—W. Whitaker, F.R.S., President, in the chair.—Prof. Emmanuel Kayser, of Marburg, was elected a Foreign Member; and Prof. Franz Lœwinson-Lessing, of Dorpat, and Prof. R. Zeiller, of Paris, were elected Foreign Correspondents of the Society.—On limestone-knolls in the Craven district of Yorkshire and elsewhere, by J. E. Marr, F.R.S. The author begins with a general account of the district, partly founded on the published work of Mr. R. H. Tiddeman, but substantiated by his own observations. The Lower Carboniferous rocks north of the Craven Fault-system differ in character and thickness from those on the south; they exhibit little disturbance on the north, but on the south they are thrown into a series of folds, while it is also on this side that the knobs of limestone called *knoll-reefs* by Mr. Tiddeman occur. The prominent features of the knolls are the crystalline character of the limestone, the horizontality of bedding in the interior of the knolls, the general parallelism of the bedding of the exterior to the contour of the knolls, and the obscurity of the bedding. Fossils, when present, are usually very perfectly preserved and undistorted; breccias are frequently found in the shales bordering the knolls and, much less commonly, in the limestone of a knoll itself. Evidence of movement in the knolls is seen in the lenticular character of the beds of limestone, in visible folded structures, the termination of lenticular beds in hooks against a divisional plane, and in the shales by the presence of a structure undistinguishable from cleavage. Dolomitised and silicified limestones are frequently associated with the knolls, and the perfection of the quartz-crystals in certain examples of the latter variety of rock suggests crystallisation during relief of pressure. The breccias belong to three main types: (1) Fragments of limestone in a matrix of similar material; (2) large nodules of black limestone enwrapped in shales; (3) various limestone-fragments in a fine calcareous paste. Examples of each type are described, and each is explained as resulting from some form of earth-movement. Breccias of similar types are found to be produced out of grit-fragments, and in places the grits are found to be piled together by faulting so as to produce knolls, which somewhat resemble those in the limestone. Dealing with the nature of the movements, the writer argues that the Middle Craven Fault is an overthrust from the north, and that the Limestone Series has undergone differential movements with respect to the hard Lower Palæozoic rocks beneath and the massive Millstone Grit above. The limestones have been squeezed-out from under the synclines, and they have accumulated under the anticlines where the pressure was relieved. In conclusion, a number of examples of knolls are cited from other localities which show similar features, such as the limestones of Keisley, Millom, and near Dalton-in-Furness, some of the Devonian limestones near Torquay, the *Leptaena*-limestone of Dalecarlia, and the Devonian limestone of Koněprus in Bohemia.—The limestone-knolls below Thorpe Fell, between Skipton and Grassington in Craven, by J. R. Dakyns. A band of limestone runs from Cracoe towards the north-east, folded in an anticline and dipping under shales. In several places the top of the limestone is brecciated and the overlying (Bowland) shale contains fragments of limestone. The limestone forms five abrupt conspicuous hills. The rocks in most of these hills are not bedded, and where they are bedded the dip is confusing; both in exposures outside of these and in adits inside, the limestone in some cases is amorphous and without any sign of bedding. The author considers the absence of bedding in the limestone to be a very important feature; for in the country south of the North Craven Fault, though the rock is excessively contorted, its bedding has not been destroyed.—On three species of Lamellibranchs from the Carboniferous Rocks of Great Britain, by Dr. Wheelton Hind. The first part of this paper describes a new species of *Anthracomya* which occurs in the North Staffordshire and Manchester coalfields at horizons higher than that characterised by *A. Phillipsi*. The fossil is found at Etruria, Bradwell, Stoke-on-Trent, and Fallow field. It appears to indicate a special zone of shales and *Spirorbis*-limestone about 300 feet below the Penkhull Sandstone, and to be the only molluscan form known from the zone. A new species of *Carbonicola* is next described, partly from specimens previously supposed to be a gasteropod, a brachiopod, or even a crustacean, and partly from better-preserved specimens obtained from calcareous bands about ten yards above the Bassey Mine Ironstone in North Staffordshire. It appears to be the latest species of this genus known, and to occur in higher beds than any other species. Lastly, a new species of *Ctenodonta* from Penton Linns (Dumfriesshire) is described. It occurs in a marine shale below the highest limestone of the locality, in beds referred to the horizon of the Hurlet Limestone by the officers of the Geological Survey. The bed contains gasteropods, crinoids, cephalopods, &c., with *Productus giganteus*. The species has some resemblance to *C. Halli*, Barrois, found in Spain.

DUBLIN.

**Royal Dublin Society**, March 22.—Prof. D. J. Cunningham, F.R.S., in the chair.—Dr. G. Johnstone Stoney, F.R.S., read a paper entitled "Survey of that part of the range of nature's operations which man is competent to study."—April 19.—Prof. G. F. FitzGerald, F.R.S., in the chair.—Prof. Letts and Mr. R. F. Blake presented the second part of their paper on the carbonic anhydride of the atmosphere, dealing with the amount and causes of variation. The authors discuss (1) the chief natural causes of evolution, (2) those of absorption, and (3) the regulating agencies, and suggest that the chief permanent natural source of evolution—namely, volcanic and subterranean emanations of carbonic anhydride—is kept in check by the absorption of the gas during rock disintegration, and eventually by cretaceous organisms which permanently remove (though of course indirectly) carbonic anhydride from the atmosphere, thus diminishing the supply of carbon necessary for the sphere of organic action. They also suggest that this "degradation" of carbon may finally lead to the extinction of all life on the globe. In the second section of the paper, the question of the temporary fluctuations in the amount of atmospheric carbonic anhydride is considered. These at the lowest estimate at times reach 10 per cent. of the total quantity. Each of the chief natural causes inducing these variations, or supposed to induce them, is discussed and the evidence reviewed; also the *rôle* which ground air plays in the phenomenon is considered. They present with the memoir a very carefully compiled list of the chief original papers which have appeared on the subject, as well as the abstracts of them.—Prof. G. F. FitzGerald communicated a paper, by Mr. D. H. Hall, on the concentration of soap solution on the surface of the liquid. This paper records the results of experiments to determine whether there is any concentration of soap solution in the superficial film of the liquid. The results showed that the soapy matter is so concentrated.—Dr. R. F. Scharff communicated a report on the Crustacea Schizopoda of Ireland, by Messrs. Ernest W. L. Holt and W. I Beaumont, in connection with the Royal Dublin Society's Survey of Fishing Grounds on the West Coast of Ireland. The report includes a complete list of all Schizopods recorded from Irish localities. Two species, *Parerythrops obesa*, G.O.S., and *Mysidella typica*, G.O.S., are added to the British list. A new genus, Dasymysis, is erected for the reception of *Mysis longicornis*, M.-Edw., Czerniavsky's genus

Acanthomysis having been defined in such a manner as to exclude the type. Reasons are given for doubting the specific validity of *Macromysis neglecta*, G.O.S., and the characters of *Erythrops serrata*, G.O.S., are re-defined.—Prof. J. Joly, F.R.S., communicated a paper, by Mr. Kingsley D. Doyle, on the Rio del Fuerte of Western Mexico and its tributaries. The paper is a valuable series of notes, arranged topographically, concerning the geology, physical geography, and meteorology of the district explored.

### EDINBURGH.

**Royal Society**, May 1.—Prof. Copeland in the chair.—Lord Kelvin's paper on the application of force within a limited space required to produce spherical solitary waves, or trains of waves, of both or either species, equivoluminal and irrotational, in an elastic solid, was briefly described. It will be found in the May number of the *Philosophical Magazine*.—Dr. Alexander Galt, in a further communication on the heat of combination of pairs of solid metals, mentioned that practically there was no heat of combination in copper-silver alloys, but that heat of combination was found in most of the copper-zinc alloys. The maximum was obtained when the metals, considered as bivalent elements, were in proportions approximating to their chemical combining proportions—about 49·8 per cent. copper. With diminishing percentage of copper, the heat of combination gradually diminished, becoming zero when there was about 30 per cent. of copper. With still smaller proportion of copper, *the heat of combination became negative*.—Dr. C. Wace Carlier read a paper on changes that occur in some cells of the newt's stomach during digestion. As soon as food is swallowed, secretion commences near the œsophagus and sweeps in a slow wave along the whole organ, reaching the pyloric glands in one to two hours. Each cell is exhausted in about four hours, following which there is a period of rest and recuperation lasting other four hours. During exhaustion, the nuclei undergo changes in size, losing chromatin, which is used up in the production of prozymogen. The nucleoli are effete products, derived mainly from the chromatin, and are extruded from the nuclei. The prozymogen passes into the cytoplasm and unites with an albuminous material to form zymogen, which is readily converted into zymin by the action of weak acids. Repair of chromatin begins by the passage into it of substances from the cytoplasm. These become gradually broken up, the nuclear radicle passing to the chromatin, and the albuminous material to the nucleoli as effete matter. When (but not until) this process is complete, the cell is again ready to recommence secretion if called upon to do so. Oxyutic cells divide by mytosis, and, in process of division, secrete zymin and form prozymogen from the chromatin just as cells not in process of division do.—In a paper on the leakage of electricity from charged bodies at moderate temperatures, Prof. J. C. Beattie described in detail results of experiments with zinc and iron plates coated with various substances. Under any given condition the rate of leakage of charge from the insulated plate was determined (1) at ordinary temperatures; (2) at temperatures of 150°–300° C. With the plate by itself or covered by certain materials there was no change in the rate of leakage as the temperature was raised. With certain coatings, however, there was greatly increased leakage at the higher temperatures. This was the case, for example, when zinc was coated with potassium bichromate and iodine; and when iron was coated with potassium permanganate or with potassium acetate.—Professor Tait, in a note on the linear and vector function, showed that if $\phi$ represented a strain with three real roots, so also did $\psi \phi \psi^{-1}$ where $\psi$ was any linear and vector function whatever. As formerly shown, $\phi$ may be written as the product, $\omega\ \pi$, of two pure strains. Hence $\psi \phi \psi^{-1} = \psi \omega \psi'.\ \psi'^{-1} \pi \psi^{-1}$, in which each triple compound is obviously self-conjugate, and hence $\psi \phi \psi^{-1}$ can also be expressed as the product of two pure strains.

### PARIS.

**Academy of Sciences**, May 15.—M. van Tieghem in the chair.—M. Prillieux took his place as a member of the Botanical Section.—Experimental application of decimal circular divisions in practical navigation, by M. E. Guyou. An account of some experiments to be undertaken on the extension of the decimal system to the instruments and tables employed in navigation. The advantages of the system and the difficulties attending its introduction are discussed.—Effects of auto-excitation of the heart by the extra-current of the electromagnetic indicator used in recording cardiac valvular movements, by M. A. Chauveau. Further experiments are described, showing the extreme sensitiveness to induced currents of the heart of the horse.—New elements of the orbit of the planet EL, by MM. Lubrano and Maitre.—Representation of uniform branches of analytic functions, by M. G. Mittag-Leffler.—Calculation of formulæ containing arbitrary functions, by M. Jules Beudon.—Want of generality in the theory of the fictitious polarisation of dielectrics, by M. H. Pellat. The theory in question is incapable of explaining the forces produced when a dielectric, originally non-electrified, is placed in an electric field.—Influence of the source of electricity in the use of Michelson's vacuum tubes, by MM. A. Perot and Ch. Fabry. The best results, as regards the production of phenomena of interference, are obtained by the use of a continuous current with an electromotive force of at least 700 or 800 volts.—On the electrolytic luminous sheath, by M. E. Lagrange.—Substitution of magnetic for mechanical action in coherers, by M. Th. Tommasina. The chains formed by the metallic particles are broken by the action of an electromagnet.—Transmission of light through turbid media, by M. P. Compan. It is shown experimentally that the nature of the light transmitted by turbid media is dependent on the dimensions of the suspended particles.—Calculation of the compressibility of a gaseous mixture from the compressibility of its components, by M. Daniel Berthelot. The method of calculation is based on Van der Waals' formula, and the theoretical numbers show a satisfactory agreement with the experimental values.—On the preparation and properties of tungsten pentabromide, by M. Ed. Defacqz. A new method for the preparation of tungsten pentabromide is described, based on the action of dry hydrogen bromide on the hexachloride at about 300° C. The satisfactory yield obtained by this process enabled the properties of the compound to be studied more completely than has hitherto been possible.—On the mixed halogen salts of lead, by M. V. Thomas. The author describes a bromochloride of the formula $3PbCl_2, PbBr_2$, obtained by mixing solutions of lead chloride and potassium bromide, a bromochloride PbBrCl formed by the action of bromine on the corresponding chloriodide which has previously been described, and a bromoiodide of the formula $3PbBr_2, PbI_2$. A bromoiodide having the composition PbBrI also appears to exist.—Separation and estimation of traces of bromine in the presence of a large excess of chlorides, by M. H. Baubigny. The bromine is separated from the bulk of the chlorine by distilling the salts with potassium permanganate and a limited quantity of hydrochloric acid. Less than 0·0005 gramme of bromine may thus be detected and estimated in the presence of 10 grammes of sodium chloride.—On the activity of manganese in relation to the phosphorescence of strontium sulphide, by M. José Rodriguez Mourelo. The influence of manganese carbonate, in rendering strontium sulphide phosphorescent, is similar to that of bismuth subnitrate as described in previous communications.—On pectins, by M. Em. Bourquelot. Five varieties of pectin, obtained from different plants, have now been examined. All are dextrorotatory to a greater or less extent, and their solutions are coagulated by pectase. On hydrolysis with dilute sulphuric acid arabinose is obtained, whilst mucic acid is formed on oxidation with nitric acid.—Action of toluylene-diamine on the red corpuscles of the blood, by MM. L. Lapicque and A. Vast. Experiments tend to show that the toxic action of toluylene-diamine is due not so much to a specific destruction of the corpuscles as to an alteration of the latter which facilitates their destruction by the hæmatolytic organs, and especially by the liver.—On the galvanotropism of ciliated infusoria, by M. Henri Mouton. The phenomenon of galvanotropism appears to be due to the direct action of the current, and not to the chemiotropic action of the products of electrolysis.—On the forms of conservation and reproduction of "black rot," by M. Joseph Perraud. It follows, from the author's observations, that burying the affected parts of the plant is of no avail unless the soil is subsequently left undisturbed.—*Botrytis cinerea* and the "Toile" disease, by M. J. Beauverie. The destructive action of the parasite is favoured by a high temperature, a moderately nutritive substratum, and a confined atmosphere saturated with aqueous vapour.—On the germination of *Neottia nidus-avis*, by M. Noel Bernard.—On a *tachylite* from the bed of the North Atlantic Ocean, by M. P. Termier.

AMSTERDAM.

Royal Academy of Sciences, March 25.—Prof. van de Sande Bakhuyzen in the chair. —Prof. Zaayer reported, both on behalf of Prof. Fockema Andreae and himself, upon a letter from the Minister of the Interior, concerning the question addressed by the Belgian Ambassador to the Dutch Government with respect to prize essays.—Prof. Pekelharing reported, both on behalf of Prof. Winkler and himself, on the paper of Dr. G. C. van Walsem, entitled "An attempt at a systematical method of the normal and pathological microscopo-anatomical and anthropological inquiry into the central nervous system." This paper will be published in the Academy's *Transactions*.—Prof. J. C. Kluyver, on reducible hyperelliptic integrals. The paper deals with the algebraic conditions to be satisfied by hyperelliptic equations, when it is possible by a theta transformation of the $r$-order to arrive at a period matrix of which the constituents, all but the first, are equal to zero. Particularly the cases $p = 2, 3$, $r = 2, 3$ are considered. An expression of the invariant relation between the branch places is given for the case $p = 2$, $r = 3$, also a proof for the special form of the reducible integral, mentioned by Prof. Burnside (*Proc. Lond. Math. Soc.*, vol. xxiii.)—Prof. Winkler, on inquiries, made by Mr. Wiardi Beckman and himself, into the influence that expiration undergoes through faradic irritation of certain sensible and sensory nerves.—Mr. Hamburger, on the influence of salt solutions on the volume of animal cells (second communication).—Prof. Van der Waals, on an anomaly in the course of the plait-point curve in the case of a mixture of anomalous substances. All these communications will be inserted in the *Proceedings*.—The following papers were also presented for publication in the *Proceedings*: Prof. Van der Waals, on volume and pressure contraction (iii.); and on behalf of Prof. L. Boltzmann, foreign member of the Academy, on the characteristic equation of Van der Waals.—Prof. Kamerlingh Onnes, on behalf of Dr. E. van Everdingen, jun., on the galvanomagnetic and thermomagnetic phenomena in bismuth (second communication).—Prof. Bakhuis Roozeboom, on behalf of Dr. Ernst Cohen, on electrical reaction velocity.

April 22.—Prof. Van de Sande Bakhuyzen in the chair.—Prof. Bakhuis Roozeboom communicated the first experiments, made for the confirmation of his theoretical views, concerning the melting points of optical isomers. These views were confirmed in the case of mixtures, both of racemic and dextro-dimethylethereal salts of tartaric acid and of the same derivatives of diacetyltartaric acid. In the first system, the inactive ester had a higher melting point than the active one; in the second system, it was just the opposite.—Prof. Kamerlingh Onnes presented, on behalf of Dr. E. van Everdingen, jun., a communication concerning the galvanomagnetic and thermomagnetic phenomena in bismuth (a continuation of the second communication).—Prof. Van der Waals presented a paper on the deduction of the phase equation, being a controversy with Prof. Boltzmann.

## DIARY OF SOCIETIES.

*THURSDAY*, MAY 25.

ROYAL INSTITUTION, at 3.—Water Weeds: Prof. L. C. Miall, F.R.S.

*FRIDAY*, MAY 26.

ROYAL INSTITUTION, at 9.—Climbs and Explorations in the Andes: Sir W. Martin Conway.

PHYSICAL SOCIETY, at 5.—On the Thermal Properties of Normal Pentane, Part 2: Prof. S. Young and Mr. Rose-Innes.—On the Distribution of Magnetic Induction in a Long Iron Bar: C. G. Lamb.

AERONAUTICAL SOCIETY, at 8.—Exhibition of Models: Lawrence Hargrave and Dr. Barton.

*MONDAY*, MAY 29.

ROYAL GEOGRAPHICAL SOCIETY, at 8.30—Explorations in Patagonia and the Eastern Andes: Dr. Francisco Moreno.

*TUESDAY*, MAY 30.

ROYAL INSTITUTION, at 3.—Recent Advances in Geology: Prof. W. J. Sollas, F.R.S.

SOCIETY OF ARTS, at 8.—The Revival of Tradesmen's Signs: J. Starkie Gardner.

ANTHROPOLOGICAL INSTITUTE, at 8.30.—On the Beginnings of Currency: Lieut.-Colonel R. C. Temple.

*THURSDAY*, JUNE 1

ROYAL SOCIETY, at 4.—Election of Fellows. —At 4.30 —*Probable Papers*: The Parent-Rock of the Diamond in South Africa: Prof. T. G. Bonney, F.R.S.—Results of Experiments in Telegony: Prof. Ewart, F.R.S.

ROYAL INSTITUTION, at 3.—Water Weeds: Prof. L. C. Miall, F.R.S.

LINNEAN SOCIETY, at 8.—On the High Level Plants of the Andes as illustrated by the Collections of Sir W. Martin Conway, Mr. Edward Whymper, and others: W. Botting Hemsley, F.R.S.—On some Australasian Collembola: Sir John Lubbock, Bart., F.R.S.

SOCIETY OF ARTS, at 4.30.—The Port of Calcutta: Sir Charles Cecil Stevens, K.C.S.I.

CHEMICAL SOCIETY, at 8.—The Hydrosulphides, Sulphides, and Polysulphides of Potassium and Sodium: W. Popplewell Bloxam.—On the Relative Efficiency of various Forms of Still-head for Fractional Distillation: Dr. Sydney Young, F.R.S.—The Salts of Dimethylpyrone, and the Tetravalence of Oxygen: Dr. J. N. Collie, F.R.S., and Thomas Tickle.

*SATURDAY*, JUNE 3.

ROYAL INSTITUTION, at 3.—The Music of India and the East, and its Influence on the Music of Europe (with Musical Illustrations): Edgar F. Jacques.

## BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—Sewage-Analysis: J. A. Wanklyn and W. J. Cooper (Paul).—Anleitung zur Darstellung Chemischer Präparate: Prof. H. Erdmann, Zweite Auflage (Frankfurt a.M., Bechhold).—Einleitung in die Vergleichende Gehirnphysiologie und Vergleichende Psychologie: Dr J. Loeb (Leipzig, Barth).—Accounts of the Trade carried by Rail and River in India, 1897–98, &c. (Calcutta).—Flora of Kent: F. J. Hanbury and E. S. Marshall (Hanbury).—A Treatise on Practical Chemistry, &c.: Dr. F. Clowes, 7th edition (Churchill).—Die Entstehung des Lebens: Dr. L. Zehnder, 1 Teil (Freiburg i.B., Mohr).—Cries and Call Notes of Wild Birds: C. A. Witchell (Gill).—Man, Past and Present: A. H. Keane (Cambridge University Press).—A Select Bibliography of Chemistry: H. C. Bolton, 1st Supplement (Washington).—Wetterprognosen und Wetterberichte des xv. und xvi. Jahrhunderts (Berlin, Asher).

PAMPHLETS.—Hey for the Holidays! (R. E. Taylor).—Sull' Impiego del Microsismografo, &c. (Venezia, Ferrari).—History and Present Status of Instruction in Cooking in the Public Schools of New York City (Washington).—The Slide-Valve Simply Explained: W. J. Tennant (Dawbarn).

SERIALS.—Zeitschrift für Wissenschaftliche Zoologie, lxv. Bd., 4 Heft (Leipzig).—Die Meteorologie der Sonne und das Wetter im Jahre 1889, &c.: Prof. K. W. Zenger (Prag, Rivnáč).—Knowledge, May (Witherby).—Journal of the Chemical Society, Supplementary Number (Gurney).—Memoirs and Proceedings of the Manchester Literary and Philosophical Society, Vol. 43, Part 1 (Manchester).—Atlantic Monthly, May (Gay).—Atti della Fondazione Scientifica Cagnola della sua Istituzione in Poi, 1896–97, 1897–98 (Milano).—Zoologist, May (West).—Physical Society of London Proceedings, May (Taylor).—Morphologisches Jahrbuch, 27 Bd. 2 Heft (Leipzig).—Journal of the Franklin Institute, May (Philadelphia)—Popular Astronomy, May (Northfield, Minn.).—Psychological Review, Monograph Supplement, Vol. 2, No. 5 (Macmillan).—American Anthropologist, April (Putnam).—Astrophysical Journal, April (Chicago).—Proceedings and Transactions of the Nova Scotian Institute of Science, Vol. ix. Part 4 (Halifax, N.S.).—Proceedings of the Academy of Natural Sciences, 1898, September–December (Philadelphia).—Annals of the Astronomical Observatory of Harvard College, Vol. xxxix. Part 1 (Cambridge, Mass.).—Royal Magazine, June (Pearson).

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THURSDAY, JUNE 1, 1899.

## EVOLUTION WITHOUT SELECTION.

*Die Farbenevolution bei den Pieriden.* Von M. C. Piepers. "Tijdschrift der Nederlandsche Dierkundige Vereenignig; 2. Deel v." Pp. 70–289. (Leiden, 1898.)

THE fact is becoming more and more widely recognised that the colours of animals, and especially of insects, afford excellent material for the investigation of dark places in the theory of evolution. As was long ago pointed out by Bates, and reiterated with increased emphasis by Wallace, the history of the modification of species is displayed to view on the wings of butterflies in a manner that is peculiarly legible and strikingly complete. There is, therefore, every justification for those students of evolution who, like Weismann, Eimer, Meldola, Poulton, Bateson, and several others, have devoted much attention to the colour patterns of lepidopterous insects, and have endeavoured with more or less success to use the facts made available by such detailed examination in the elucidation of the laws which govern the origin and development of species.

The pamphlet named at the head of this article is the work of an author whose credentials entitle him at least to an attentive hearing. He has resided for nearly thirty years in the Malay Archipelago—chiefly in the island of Java; during the whole of which time, as he tells us, he has studied the entomology of that region, and has in particular continued to search for explanations of the various phenomena presented by the colours of its lepidopterous fauna. It might be expected, then, that he would be able to bring forward a mass of valuable material derived from such observations and experiments as can best be carried out amid the natural surroundings of tropical species, and would thus be in a position to afford real help towards the solution of questions like those of the value in the struggle for existence of mimetic or of warning colours, the importance of sexual selection and the protective significance of seasonal modifications. So far from this being the case, however, it must unfortunately be stated that he has done little or nothing to increase our knowledge in any of these or similar directions.

The cause of his failure is not far to seek. Being, as he informs his readers, in most respects a follower of Eimer, though disagreeing with his master on certain points of detail, he looks for an explanation of organic evolution in the direction of "laws of growth," uncontrolled by any process of selection, but working out the transformation of species under the influence of external conditions which act upon organisms of varying degrees of susceptibility. The essence of his contention is the non-recognition of selection in any form as a factor in evolution, and he is apparently so sure of his position on *à priori* grounds, that he has not thought it worth while to keep the selection hypothesis in view even as a provisional basis for observation and experiment. This, the πρῶτον ψεῦδος of his position, has had a most disastrous effect upon his work, both as an observer and as a reasoner. It cannot be said that he has any new arguments of weight to bring forward; the main part of his treatise is taken up with a laborious attempt to show that the course of colour-evolution in the Pierids (or "white" butterflies) has followed, and is following, a definite succession of stages, which continually occur in the same order. Starting from an original red, the process of colour-change in the Pierids, according to Piepers, is always tending to reach a final stage of white, which may be attained either by means of a gradual paling through orange and yellow, or through an intermediate condition of black. This inevitable tendency, arising from an internal impulse towards change in a definite direction, taken in conjunction with external influences which act chiefly by way of accelerating or retarding the process of change, and in relation with individual differences of susceptibility to stimulus, he believes to have been sufficient for the production of the assemblage of diverse forms which constitute the Pierid sub-family as at present existing.

It is no doubt true that, speaking generally, there has been a fairly uniform tendency throughout this group of butterflies towards the replacement of an original dark by a white pigment. But this was not reserved for Piepers to discover, inasmuch as the view in question has been long ago advanced and supported by much more detailed evidence than that brought forward in the present treatise. Moreover, cases have been pointed out where, in consequence of mimetic adaptation or from other causes, the more usual process of change has been reversed or modified—a fact not noticed by Piepers, and not very favourable to his general view. But acquaintance with the work of his predecessors scarcely appears to be a strong point with the author, who frequently either ignores altogether, or dismisses in a curt sentence or two, results of other observers which certainly demand and deserve a careful comparison with his own. The part of his theory for which he really is entitled to claim originality, viz. that the primitive colour of Pierids was a uniform shade of red, seems to rest on extremely slender evidence. To any one who will take a comprehensive view of the whole sub-family, the conclusion from which Piepers does not shrink, viz. that the male of *Appias* (*Tachyris*) *zarinda* most nearly represents in coloration the earliest form of Pierid, will appear to savour of the *reductio ad absurdum*. Without going into the kind of detail which would here be out of place, we may safely assert that there is abundant evidence in favour of the contrary view; and that in many cases, at all events, as in the genera *Mylothris* and *Dismorphia*, there is every reason to attribute the presence of much of the red or orange coloration rather to increased specialisation for a distinct purpose, viz. that of mimicry, than to reversion or survival. Hopkins's researches on Pierine pigments are not unknown to Piepers, but the latter, perhaps wisely, refrains from attempting to reconcile them with his own conclusions.

This brings us to what appears to us to be a serious offence on the part of the author against good taste and good manners in scientific controversy. Nothing but gratitude is due to him for the facts that he has recorded from his own experience; most readers, indeed, will only wish that he had given us more of them. Nor can any one fairly complain of his absolute denial of the modifying influence of selection, even though he thereby puts him-

self in opposition to Darwin, Wallace, Fritz Müller, Weismann, and most of those whose labours have contributed to the establishment of the theory of evolution. But in speaking of views which he does not himself hold, he repeatedly allows himself to use language which is highly unbecoming in a scientific man. This is especially noticeable in his remarks on the subject of mimicry. We are of course prepared to find that he does not believe in it, but it might be thought that a view which commended itself to Bates, Wallace, F. Müller, and Trimen, to say nothing of Darwin himself, was at least deserving of respectful treatment. M. Piepers does not think so, and his language on the subject is so uncontrolled as to suggest doubts whether, in spite of his training as a jurist, he can be considered a fair and competent examiner of evidence. It is easy enough to throw about words like "Aberglaube" and "Humbuglehre" in reference to the views of other workers, and to suggest that opponents are "mentally abnormal"; but such expressions recall the methods of the advocate rather than of the judge, and they render their employer liable to severe retaliation, did any one care to administer it.

A conspicuous instance of this want of restraint occurs in the note on p. 279; where the author altogether overreaches himself in his denunciation of Schröder. It is not our business to correct his literary blunders, but we cannot help thinking that the original utterer of the famous line "homo sum; humani nil a me alienum puto" (misquoted, by the way) would be somewhat surprised to see himself referred to as "the old philosopher." This, however, may pass; more open to question is the wisdom of introducing the quotation at all. M. Piepers seems to think that the upholders of mimicry will be "angry" at his strictures. They are more likely to be amused, and perhaps a little saddened, for there is always an element of pathos in resistance to the inevitable.

Protective resemblance, in relation to selection, fares no better with the author than mimicry itself. Thayer's demonstration of the protective value of the pale underside of birds and mammals is convincing enough for most minds; Piepers simply dismisses it with the remark that he cannot admit it in the case of insects. One is tempted to ask him what he expected in the case of insects, but this dictum is a not unfair specimen of his critical method generally. It is difficult to answer a disputant who holds (p. 250) that the resemblance to forms of vegetation shown by the underside of *Euchloe cardamines* and even of *Kallima paralecta* is accidental. The somewhat unseemly comparison on the same page is perhaps meant for a joke. If so, it says very little for the author's humour; if not, it says even less for his logic.

The treatment of seasonal forms affords another instance of his curious reluctance to accept the plain and obvious explanation of certain facts, if that explanation involves a recognition of the principle of selection. Some of his remarks on the varying forms of Malayan butterflies have all the interest and importance which naturally belong to the personal observations of a good field naturalist, but it is strange to find him still advancing theories of the direct influence of local conditions which were long ago discarded by Wallace. The truth which underlies his statements is probably this—that polymorphism gives an opportunity to selection, under which influence it may become limited by locality and season. In his discussion of the permanent or variable whiteness of certain animals, he cannot of course shut his eyes to the fact that the same visual effect of whiteness is produced in different cases by different means. He remarks in a somewhat puzzled way that there is nevertheless evidently some connection between the whiteness caused by a white pigment (so-called) and that due to scattered reflection. Of course there is, or may be, such a connection; but the obvious key to the mystery, viz. selective adaptation, is not even noticed by him.

It is really pitiful to witness the straits to which those evolutionists are reduced who desert the firm and clear lines laid down by Darwin. Towards the end of his treatise M. Piepers makes a certain appeal for the indulgence due to an amateur. We are inclined to admit his claim, and to judge him leniently on that account. Courage and candour he does not lack, and it is deplorable that having tasted the "Pierian spring," he has not taken a deeper draught of its waters. A little more reading would have shown him that many of his discoveries had been already made, and that most of his difficulties had been answered by anticipation.

F. A. D.

## *PROFESSOR TAIT'S COLLECTED PAPERS.*

*Scientific Papers.* By Peter Guthrie Tait, M.A., Sec.R.S.E., &c. Vol. i. Pp. xiv + 498. (Cambridge University Press, 1898.)

THE Cambridge Press has already laid mathematical and physical workers under deep obligations by its editions of Maxwell, Stokes, Thomson, and Cayley. It now proposes considerably to extend these obligations, and as an instalment of their fresh enterprises we have here the first volume of the collected papers of Prof. Tait. This reprint appeals to readers of widely different interests, and will be welcomed by all, not only on account of the highly specialised investigations of various kinds which it contains, but also as a monument to a writer to whom science owes a great deal.

It would be out of place, even if the reviewer were competent, to attempt any detailed examination of the papers here presented. They have been before the world for many years, and their value and originality have not been contested. A rapid sketch of the contents may, however, be given. A large proportion of the book is taken up with the quaternion investigations in which Prof. Tait first made his mark, and to which he has returned from time to time with undiminished enthusiasm. The precise scope and value of the quaternion method are questions on which opinions have greatly differed, and the number of mathematicians otherwise eminent who could be reckoned as fully concurring in Prof. Tait's views on these points is probably very limited. In this country there has been a certain natural diffidence, and perhaps a little want of courage, which have hindered the free expression of opinion; but on the continent the assertion has been made again and again that the subject has in some respects been unfortunate in its expositors, and that the elements of undoubted value in the theory have been unduly discredited by the somewhat excessive claims made on its behalf. It is possible to sympathise

with this view, and yet to attach very high importance to the investigations now in evidence. They are concerned mainly with the processes of differentiation and integration as applied to quaternions, and especially with the properties of Hamilton's operator

$$i\frac{d}{dx}+j\frac{d}{dy}+k\frac{d}{dz},$$

a branch of the subject which (as is well known) has exercised a great fascination on many distinguished cultivators of mathematical physics, from Maxwell downwards. That Prof. Tait's papers remain the primary, and indeed almost the sole, authority on such matters, is ample warrant for the present republication. For the rest, a few items gathered from the titles, such as Fresnel's Wave-Surface, the Theory of Electrodynamics, the Theory of Strain, the Dynamics of Rotation, Green's Theorem, Isothermal Surfaces, and Minding's Theorem, will indicate the variety and importance of the subjects which Prof. Tait has sought to bring within the range of this ambitious calculus.

Passing from this group, we have to notice an elaborate investigation on "Knots," suggested originally by Thomson's theory of vortex-atoms. It deals with a branch of the Geometry of Position which few mathematicians (and those only of the ablest) have ventured to touch; and although the presentation disclaims any finality, there can be no doubt that Prof. Tait's investigations must be accounted a solid and valuable, as they are an interesting contribution to the subject.

It would be ungrateful to pass over a number of minor papers which are specially characteristic of Prof. Tait in respect of the symmetry and elegance of the mathematical treatment, or of the manner in which new light is thrown on well-worn topics. Of these the papers on Hamilton's Characteristic Function, and on the Hodograph, may be cited as specimens. In this latter we find the now well-known representation of a small oscillation in a resisting medium as the projection of motion in an equiangular spiral, as well as several other results or modes of proof which have long become common property. It is pleasant to be reminded of their real source.

A very attractive topic is treated alike with originality and elegance in the paper on "Mirage."

There remain the experimental papers. Of these it may be sufficient to here say that those on Thermo-Electricity have long ranked as classics; and that the paper on the pressure-errors of the *Challenger* thermometers is an interesting record of a laborious investigation undertaken to decide a very important practical question.

Some readers may perhaps be disappointed to find that one side of Prof. Tait's activity is not represented in these pages. He has in his time been engaged in many keen controversies, in which he has displayed the qualities of a "first-class fighting man." One cannot but feel, therefore, great admiration for the restraint he has shown in omitting all traces of such incidents from the present record of his work. There is, in fact, only one paper which one would willingly have spared, and that for quite other reasons. The lecture on "Force," with its insistence on what after all are verbal questions, is surely out of place in the present collection. The readers who are capable of following the *technique* of quaternions, or the intricacies of amphicheiral knots, do not need to be lectured on the looseness of newspaper language; whilst the grave discussion as to whether force or energy has the greater title to rank as a "thing" will hardly excite in them any other feeling than the amusement which (one suspects) may have been the real object of the whole discourse.

The printing and general appearance of the volume are beyond praise. One might, indeed, protest that the *format* is a little *too* luxurious. Many persons hold to the view that the octavo form adopted in the cases of Stokes and Thomson is far more handy and convenient for real work than the more imposing quarto. In the case of Cayley, the larger form was perhaps required by the nature of the subject-matter, with its long algebraical formulæ; but there is little in the present collection which could not with a little ingenuity have been accommodated in the smaller page. But such criticisms are, after all, somewhat ungracious. We conclude by thanking the University and Prof. Tait for this very acceptable volume, which we trust to see speedily followed by a second. And we venture to suggest to the University Press that an additional and welcome element of interest would be imparted to these reprints if they could be adorned with portraits of the authors, even when these are happily still amongst us. HORACE LAMB.

## OUR BOOK SHELF.

*Elementary Physiology.* By Benjamin Moore, M.A. With 125 Illustrations. Pp. vi + 295. (London: Longmans, Green, and Co., 1899.)

THIS book contrasts favourably with most others of its class. A small treatise of three hundred pages on elementary physiology can scarcely avoid being superficial, and, from the students' point of view, inadequate; but to these inevitable shortcomings there are too often added, in books of the kind, the quite gratuitous defects of inaccuracy in statement and failure to keep up with the advance of knowledge. From faults of the latter description the work before us is practically free, and it may be commended with confidence to the junior student, who, as the author says, "is often plunged into a mass of detail, and gets so involved in this, that he loses sight of the main outstanding features of the subject." Most teachers of physiology have probably had experience among their pupils of the mental condition here referred to. Lucid and concise in statement, Mr. Moore's book manages to convey a large amount of accurate information in very small compass. It bears ample evidence of being no mere literary compilation, but the production of a genuine worker in physiology, whose mode of treatment is often striking and original. As might be expected from the author, the book is especially strong in such matters as digestion, absorption and metabolism.

The volume is in most respects so meritorious that it seems ungracious to call attention to its blemishes. These are, as a rule, not serious. It would be unfair to find fault with a book of this kind for being dogmatic; it is plainly not a fitting place for the discussion of controverted questions. The statement, however, on p. 14, with respect to the relations of cartilage and bone is distinctly misleading. But with few exceptions the points that call for criticism concern the form of the book rather than its matter. Thus, the author is occasionally guilty of an awkwardness or inelegance of language that might easily have been avoided, and we cannot say that we approve of such colloquialisms as "harking back again to our simple type," or "that bigger supply of

blood to the cells which is required." In many places the sense is seriously interfered with by faulty punctuation, and we note a rather plentiful crop of misprints, especially towards the end of the book. Such are "centre nervous system," "tircuspid," "vertebræ," (for "vertebrata"), "cauda equinæ," "straining" (for "staining"), "Weber-Feehner law," "fenestra rotundis," (several times repeated), "scala tampani," "selerotic," "viteous humour." Nor do we care for the form "oculimotor." It is to be hoped that a future edition will be more carefully revised. The author has been fortunate in securing the use of the well-known and admirable figures from Quain's "Anatomy" and Schäfer's "Essentials of Histology." They add materially to the value of the work.

*The Dawn of Reason.* By James Weir, jun., M.D. Pp. xiii + 234. (New York: The Macmillan Company, London: Macmillan and Co., Ltd., 1899.)

THIS book on the mental processes of animals is the fruit of much original observation, and in many cases this observation has been supplemented by experiment; but, unfortunately, all the author's results are vitiated by his uncritical and biased attitude in favour of an extreme view of the mental life of animals, and there are few of his facts which the comparative psychologist would be justified in using without ample corroboration by other observers. Instinct is regarded as the great bane of psychology, and it almost seems as if the author believed it to be a special invention of those whom he calls "creationists." He poses as an ardent evolutionist, but is so blind to the most elementary principles of the evolution of mind that when a water-louse frightens some rhizopods, he can only conclude either that the latter have eyes and ears so small that lenses of the highest power cannot make them visible, or that these creatures are the possessors of senses utterly unknown to and incapable of being appreciated by man. He makes observations on spiders which show that they are differently affected by loud and soft vibrations of an organ—observations which do not even demonstrate the existence of hearing—and concludes that these animals have attained a very high degree of æsthetic musical discrimination. He has also seen a spider "intentionally beautifying" its web with flakes of logwood, and he has watched rhizopods employing their time in "simple amusement" resembling a game of tag. Nevertheless, among these extravagances, one meets with observations which would be of distinct value and interest if one had confidence in the observer.

*The Arithmetic of Chemistry.* By John Waddell, B.Sc. D.Sc. Pp. viii + 133. (New York: The Macmillan Company. London: Macmillan and Co., Ltd., 1899.)

THE volume does not differ essentially from other books on chemical arithmetic. Every teacher has his own method of presenting an arithmetical problem, which he often feels impelled to share with others. The author's methods seem thoroughly sound and logical, and no exception can be taken to them. There is a good deal to be said, too, for the plan of treating the calculations on a purely experimental basis independently of theories; but it is not always advisable to hold to it too rigidly. A good illustration is offered by the following example.

The author begins by showing that the combining weight of oxygen taken as 8 is thoroughly satisfactory, not only in its relation to hydrogen (1) in water, but to carbon (6) in its two oxides. It then becomes necessary to explain that this number for oxygen does not fulfil the expectations which it first raised, and that the formula for water HO(9) must be discarded in favour of $H_2O(18)$. "It is found that while by electrolysis of water all of the hydrogen that is in the water is set free as a gas, and $\frac{1}{9}$ of the water decomposed is hydrogen; on the other hand, when sodium acts on water, only one-half as much hydrogen is set free, that is $\frac{1}{18}$ of the weight of water acted upon." It is questionable whether this explanation would carry conviction to the beginner. A plain dogmatic statement would surely serve the purpose better, until the student had advanced to a stage when he could grasp the whole question involved. The author has collected together an excellent set of examples from a variety of sources, which should be useful to teachers in elementary classes. J. B. C.

*The Flora of Cheshire.* By the late Lord de Tabley (Hon. J. Byrne Leicester Warren), edited by Spencer Moore; with a Biographical Notice of the Author by Sir Mountstuart Grant Duff. Pp. cxiv + 399, with a portrait of the author and a map of the county. (London: Longmans, Green, and Co., 1899.)

THE manuscript of this "Flora," we are told, was completed a quarter of a century ago. Those who knew the sensitive, retiring disposition of the late Lord de Tabley will not be surprised that he laid it aside as not ready for press; nor will they be surprised at the excellence of what was done. There is little beyond an enumeration of the plants of the county, but made with extreme care and with conscientious acknowledgment of doubts and difficulties in dealing with critical plants.

Two classes of vegetation seem particularly to have attracted the author's notice, and both in a decidedly historical aspect. The one class is that of the alien plants, whose spread from ballast-heaps, &c., is traced; the other is the shore vegetation of a coast which has been much changed both by man and by tidal denudation. There probably exists no "Flora" of any county in Britain which approaches it in interest in either respect, unless it be that of Middlesex by Trimen and Thiselton-Dyer, published in 1869 at the time when Lord de Tabley was at work on what has just been printed.

To the matter which was put into his hands, the editor has wisely added enough to bring the work into line with our present knowledge of Cheshire botany. The biographical notice in its want of facts is a little disappointing; and the attempt to give each plant a binomial English name leads one to a curious and not altogether happy result. These, however, are small matters.

I. H. B.

## LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### Fourier's Series.

THE statement of Fourier's theorem for the special case which has intermittently for some months past been a subject of discussion in NATURE, is as follows:—The function whose value is $\frac{1}{2}(\pi - x)$, when $x$ lies between 0 and $\pi$, and $-\frac{1}{2}(\pi + x)$, when $x$ lies between 0 and $-\pi$, can be expressed by the series $\sum_{k=}^{k=\infty} \frac{\sin kx}{k}$ for values of $x$ which lie between $\pi$ and $-\pi$.

The proof of the theorem, whether in this special case or in more general cases, consists in summing the series; and the result obtained in this special case is that the sum of the series is

$$\begin{array}{ll} \frac{1}{2}(\pi - x), & \text{when } x \text{ lies between 0 and } \pi, \\ -\frac{1}{2}(\pi + x), & \text{when } x \text{ lies between 0 and } -\pi, \\ 0 & \text{, when } x = 0. \end{array}$$

Prof. Michelson has found a difficulty in this result in that, whereas the sum of any number of terms of the series is a continuous function of $x$, the sum of the series is a discontinuous function of $x$. If I have not misunderstood him, he contends that for extremely small positive values of $x$ the sum of the series should be regarded as indeterminate and as having any value between 0 and $\frac{1}{2}\pi$, and I understand him to support this contention by the consideration that when $n$ terms of the series are taken, so that $x$ being extremely small $nx$ is finite, such an indeterminateness is found.

Such a position involves a misconception of the meaning of

the "sum of an infinite series." When $u_1 + u_2 + \dots$ is the series, the terms being uniform functions of $x$, the sum of the series for any value of $x$ is the limit of the sequence of numbers $u_1$, $u_1 + u_2$, $u_1 + u_2 + u_3$, ... in each of which $x$ has the given value; the limit of the sum of the series when $x = 0$, is the result obtained by *first* summing the series for a finite value of $x$, and *afterwards* diminishing $x$ without limit; the sum of the series when $x = 0$ is the result obtained by *first* substituting 0 for $x$ in the functions $u_1$, $u_2$, ... and *afterwards* forming the limit of the sequence $u_1$, $u_1 + u_2$, .... In the example in question, the results thus obtained are $\frac{1}{2}\pi$ and 0 respectively. The results that can be obtained by summing the series to $n$ terms, diminishing $x$ indefinitely, increasing $n$ indefinitely and keeping $nx$ finite, generally do not coincide either with the sum for $x = 0$ or with the limit of the sum for $x = 0$, when these are different. Such results may, as I have pointed out in a previous letter, be useful for purposes of illustration, but they are quite beside the mark when it is a question either of the statement of Fourier's theorem or of the sum of Fourier's series.

M. Poincaré, in his letter printed in NATURE for May 18, does not assert that the sum of the series can be obtained by allowing $x$ to approach zero and $n$ to increase at the same time, in such a way that $nx$ remains finite; but he states that Prof. Michelson is perfectly right in contending that the result of this process is indeterminate. So far as I am aware this contention has not been called in question in the course of the discussion.

Oxford, May 19. A. E. H. LOVE.

## Bessel's Functions.

THE remarks of "C. G. K." (p. 74) concerning the defects of style which are frequently observed in the writings of scientific men, lead me to point out a grammatical error which is creeping into mathematical literature. I allude to the use of the incorrect phrase "Bessel Functions" in the place of "Bessel's Functions."

In certain cases the name of a person may be converted into an adjective by the addition of an appropriate termination, of which such words as *Elizabethan* and *Victorian* are examples; but to use the name itself (which is a noun) as an adjective, is a violation of one of the most elementary rules of grammar.

When the conversion of a proper noun into an adjective would be cumbrous or inelegant, the only correct mode of expression is to use the *genitive* case. If, therefore, we reject such an adjective as "Bessellian" on the ground of its inelegance, we must use the phrase "Bessel's Functions," that is functions of Bessel. The absurdity and incorrectness of the phrase "Bessel Functions" is at once seen by comparing it with such phrases as "*Green* Theorem," "*Chrystal* Algebra," "*Love* Elasticity."

The correct use of the genitive case is a subject upon which considerable misapprehension has existed. Thus we find in the Prayer Book the phrase "For Jesus Christ His sake," instead of "For Jesus Christ's sake." The error arose from the fact that the compilers of the Prayer Book were ignorant that the *'s* is not a conception of the pronoun *his*, but is the old Teutonic genitive which still exists in most German languages.

Fledborough Hall, Holyport, May 28. A. B. BASSET.

## "The Art of Topography."

IN your issue of March 23 (No. 1534, vol. lix.) appears a review of "Recherches sur les Instruments, les Méthodes et le dessin Topographiques, par le Colonel A. Laussedat," signed by "T. H. H." The review brought to my attention several points of interest upon which I beg leave to comment.

Regarding planetable instruments, the reviewer says "that 'Russians and Americans' use very complicated instruments." Of the Russian instruments I have no knowledge, but this is certainly not true of the American.

The U.S. Geological Survey makes use of the planetable to a greater extent than any and all other organisations in America, fully two hundred of these instruments being constantly in use.

The instruments used are remarkable in simplicity and efficiency, are reasonably light, portable and accurate. The instruments are of a model designed by Mr. Willard D. Johnson, of the Survey, and are fully described on pages 79 to 89 of *Monograph* xxii. of the U.S. Geological Survey, entitled "Manual of Topographic Methods," by Mr. Henry Gannett.

This work also treats of the methods of accomplishing topographic mapping by the Geological Survey. Mr. Gannett explains the use made of the planetable, and shows that all work is controlled by points, located by triangulation or other means dependent upon numerical measurements and carefully computed. The triangulation is carried on with eight-inch theodolites reading, by micrometer microscopes, to two seconds.

The instructions to triangulators include the order that points must be selected and arranged so as to best control the area under survey, and that *three* points at least should be located on each atlas sheet of the map. Since these sheets differ in area in different parts of the country, ranging from 1/16 of a square degree to a square degree, the distance between triangulation stations necessarily varies considerably.

After the primary triangulation points are located in an area, dependence upon the planetable is absolute for the "secondary" triangulation within that area, the control, both horizontal and vertical, is carried on by use of this instrument. If the surveyor using a planetable for graphic work starts from accurately located points with check point available, he very soon discovers any "accumulation of error," in that it is impossible to make the several locations check one with another.

In regard to the use of "continuous contours" to express relief, the "Commission of 1826" seems to have drawn the remarkable conclusion that for scales less than 1 : 10,000 this system is insufficient.

The Geological Survey publishes topographic maps which vary in scale between 1 : 9600 and 1 : 250,000 (1 inch to 800 feet and 1 inch to 4 miles about, respectively), and on these maps the contour interval varies between 5 feet and 200 feet. The expression of relief is, I think, in these cases satisfactory, at least so far as giving accurate information is concerned; the artistic effect is very good also, especially when the topographic features are large and the slopes steep, cliffs appearing as broad heavy lines where differentiation of the individual contours is impossible.

About 1890, the use of mercurial barometers was abandoned by the Geological Survey, and trigonometric methods for obtaining heights were adopted. At the present time the primary heights are determined by spirit-levelling, from which elevations are carried in connection with the triangulation or by lines run with vertical angle readings and carefully measured distances. The use of the aneroid barometer is only allowed in inaccessible areas between the known elevations, and must be frequently checked. The experience of the writer in widely separated regions in the United States, in obtaining differences of elevation with the aneroid, leads him to the conclusion that, as a rule, the instrument fails to record differences as accurately when carried from a higher to a lower region as it does when the change of elevation is in the opposite direction. Also, that an aneroid which has been used in a region of elevation of given range must be given time to accommodate itself, if it be required to do good work in a region of greater or less elevation than that in which it has been used. The principle and construction of the aneroid is such that it never can be accepted as an instrument of precision except within well-defined limits, with frequent comparison with known elevations. The Survey has in use several hundred aneroid barometers, but no confidence may be had in any one of them unless frequently checked, as stated. It will be seen that the methods now in use in America agree more closely with those practised by the British Government, at least so far as the Colonial surveys are concerned, than with any other of the European surveys. R. H. C.

## The Heating of the Anti-Kathode in X-Ray Work.

SINCE the beginning of X-ray work the heating of the anti-kathode has caused great difficulty, and with the introduction of the Wehnelt interrupter it is even more important that this should be prevented. In other words, we all along have had more energy from the coil than could be utilised in the Crookes' tube. Many workers like myself have tried to remedy this, and various plans have been adopted to keep the anti-kathode cool. It occurred to me that if we could get a piece of platinum, fused into the glass tube itself, to act as the anti-kathode, and placed opposite the kathode, this object might be attained. Such a tube, after many attempts, has at last been made; and although the first experiments have only been successful in making small tubes, others of a larger size are at present being attempted. The advantage of this method will easily be seen, because the heating of the piece of platinum can be prevented by placing the whole tube in a fluid cooling mixture or otherwise. These tubes are difficult to make at present, but I possess one which has retained its vacuum for some weeks.

179 Bath Street, Glasgow, May 28. J. MACINTYRE.

## Variation of Species.

ON p. 181 of Wallace's "Darwinism," ed. 1889, this passage occurs:—"Let us suppose that a given species consists of 100,000 individuals of each sex, with only the usual amount of fluctuating external variability. Let a physiological variation arise, so that 10 per cent. of the whole number—10,000 individuals of each sex—while remaining fertile *inter se* become quite sterile with the remaining 90,000. This peculiarity is not correlated with any external differences of form or colour, or with inherent peculiarities of likes or dislikes leading to any choice as to the pairing of the two sets of individuals. We have now to inquire, What would be the result?"

I have here attempted to investigate this question algebraically.

A. We shall suppose, as Dr. Wallace does, that the number of males in the species is the same as the number of females. Each of these numbers we shall denote by unity. For convenience, we shall speak of the number of either sex as the number of the species. Let then

$x$ = the number of the normal species,

and

$y$ = the number of the variant variety,

at any given stage of the change above described.

If in any given generation $(x, y)$, the ratio, which the number of the variant individuals, born in a family of the normal species, bears to the total number of young born in that family, be denoted by $k$; and if $(x', y')$ denote the generation which succeeds $(x, y)$; then must

$$x' : y' :: x^2(1-k) : y^2 + kx^2;$$

with the relation

$$x' + y' = x + y = 1;$$

because the total species remains constant in number of individuals.

Now, if the variants succeed in establishing themselves as a new species, and the above two generations belong to the permanently settled state of the whole species, we must have $x' = x$, and $y' = y$.

Consequently, to determine $x$, $y$ under this condition we have the equations

$$\frac{(1-k)x^2}{x} = \frac{y^2 + kx^2}{y},\quad x + y = 1;$$

$$\therefore\ (1-k)x = 2x^2 - 2x + 1;$$

$$\therefore\ x = \tfrac{1}{4}(3 - k \pm \sqrt{k^2 - 6k + 1}).$$

To take Dr. Wallace's example, put $k = \cdot 1$. Then

$$x = \cdot 88508\ \ldots,\quad y = \cdot 11492\ \ldots;$$

or

$$x = \cdot 56492\ \ldots,\quad y = \cdot 43508\ \ldots.$$

Thus, taking Dr. Wallace's number 100,000, we find that, ultimately, the normal species will number 88,508 and the variant 11,492 These numbers differ but little from Dr. Wallace's, but they represent the final distribution of the original species into two species. Another possible distribution is given by the numbers 56,492 and 43,508. If by any chance the first permanent distribution be disturbed materially, then the total species might reach the second permanent state.

If, however, at any time the parent species were to cease to produce the variants, then the latter would quickly disappear. They could be saved from extinction only by the ceasing of intermarriage between the two species. For, if $(x_n, y_n)$ denote the $n$th generation from the one $(x, y)$ in which the variants ceased to be produced by the normal species, then

$$x_n : y_n :: x^{2^n} : y^{2^n}.$$

If $n = 4$, and $x = \cdot 9$, $y = \cdot 1$, as in Dr. Wallace's case, then

$$x_4 : y_4 :: (\cdot 81)^4 : \cdot 00000001;$$

so that the original species of 100,000 would have no variants left at all. The disappearance of the variants is due to the two facts, (1) that the total number of the two species together is constant, (2) that the number of unfruitful unions is very large in proportion to the number of unions possible to the smaller species. For example, if the variants be ·1 of the whole species, the probability will be that ·9 of their unions will be unfruitful; but that ·9 of the unions of the normal species will not be unfruitful.

B. We shall now consider the case when the unions between the two varieties are not sterile, and the hybrids are also fertile *inter se* and with the parent varieties.

Let the relative, effective, fertility of the hybrids and mongrels, *inter se* and with the parent varieties, be denoted by the factor $k$, which we shall assume to be always less than unity. Also, let the effective fertility of the normal species in the production of variants be denoted by the factor $\mu$; and let $z$ denote the number of the hybrid variety in the generation $(x, y, z)$.

Then the equations which determine the stable and permanent condition, if there be one, are

$$\frac{(1-\mu)x^2}{x} = \frac{y^2 + \mu x^2}{y} = \frac{\{(x+y+z)^2 - x^2 - y^2\} \times k}{z},$$

$$x + y + z = 1. \qquad \ldots\ldots\ldots (1)$$

Put

$$\alpha = 1 - z,\ k' = 1 - k,\ \mu' = 1 - \mu;$$

then

$$\mu' x(1 - k'\alpha) = k, \qquad \ldots\ldots\ldots (2)$$

and

$$\mu' x\alpha = x^2 + (\alpha - x)^2. \qquad \ldots\ldots\ldots (3)$$

Put

$$\beta = (1 - k'\alpha)\mu'\alpha; \qquad \ldots\ldots\ldots (4)$$

then

$$\beta^2 - k(3-\mu)\beta + 2k^2 = 0. \qquad \ldots\ldots (5)$$

Whence

$$\alpha,\ \text{or}\ 1 - z, = \frac{1}{2k'}\left\{1 \pm \sqrt{1 - \frac{4k'\beta}{\mu'}}\right\}, \qquad \ldots (6)$$

and

$$\beta = \frac{k}{2}\left\{3 - \mu \pm \sqrt{\mu^2 - 6\mu + 1}\right\} \qquad \ldots\ldots (7)$$

The roots of $\mu^2 - 6\mu + 1 = 0$ are ·17158 . . . and 5·82842 . . .

As we suppose $\mu$ less than 1, it follows that in no case must $\mu$ exceed the lower root, ·17158 . . . . . . . . . . . . (8)

From (7) it follows that $\beta$ must $> k$.

From (6) it follows that $1 - \mu$ must $> 4k'\beta$, or $= 4k'\beta$;

$\therefore\ 1 - \mu$ must $> 4kk'$; $\therefore\ k$ must not $> \cdot 5$ . . . . . (9)

Also $\beta$ must not $> \dfrac{\mu'}{4k}$, . . . . . . . . . . . . . . . (10)

To take Dr. Wallace's example, put $\mu = \cdot 1$.

We find, then, that $kk'$ must not $> \cdot 225$. If we put $kk' = \cdot 225$, and solve for $k$, we find that

$$k = \cdot 342\ \ldots,\ \text{or}\ \cdot 658\ \ldots.$$

But $kk'$ must not $> \cdot 225$; hence $k$ must not lie between ·342 . . . and ·658 . . .; ∴ by (9) $k$ must not $> \cdot 342$ . . .

Take, for example, $k = \cdot 2$.

Then by (7), $\beta = \cdot 225969$ . . . or ·354031 . . . .

By (10) we must reject the second value of $\beta$.

Adopting the first value, we find from equations (2) and (1) the following two solutions,

$$x = \cdot 798\ \ldots,\ y = \cdot 104\ \ldots,\ z = \cdot 098\ \ldots$$

and

$$x = \cdot 308\ \ldots,\ y = \cdot 040\ \ldots,\ z = \cdot 652\ \ldots.$$

Here the effective fertility of the hybrids, *inter se* and with the parent varieties, must not exceed 34 per cent. of that of the parent varieties; and in no case must it exceed 50 per cent. of the latter. Also, in no case must the parent species supply more than, or even as much as, 18 per cent. of its total progeny to the variant species.

C. If no hybrid unions occur, and the two varieties supply individuals to each other in such a way that, taking the progeny of the generation $(x, y)$, a fraction $\lambda$ of the $x$ progeny belongs to the $y$ variety, while a fraction $\mu$ of the $y$ progeny belongs to the $x$ variety (where $\lambda$ and $\mu$ are proper fractions), it is easy to prove that in the ultimate, established, state of the total species

$$x : y :: \mu : \lambda.$$

Therefore, if $\lambda = \mu$, the species will be, in its final state, equally divided between the two varieties. The equations for the established state are, since now there is no intermarriage,

$$\frac{x - \lambda x + \mu y}{x} = \frac{y - \mu y + \lambda x}{y},\quad x + y = 1;$$

whence

$$\lambda x = \mu y;$$

*i.e.*

$$x : y :: \mu : \lambda.$$

This may also be proved by direct calculation.

Woodroffe, Bournemouth. J. W. SHARPE.

## ON SOME RECENT ADVANCES IN SPECTRUM ANALYSIS RELATING TO INORGANIC AND ORGANIC EVOLUTION.[1]

IN the last lecture I dealt with that new development of spectrum analysis which has enabled us to discuss, with greater fulness than was possible before, the various chemical conditionings in the different regions of our system as marked out for us by the Milky Way. I now have to refer to another development in a somewhat different direction. We have, as I think you will agree, by the discussion of the relation of the celestial bodies of all sorts to the Milky Way, demonstrated that the evolution of the cosmos in all probability took place from the gradual condensation of swarms of meteorites; and that such swarms are still more numerous there, and give rise to the new stars, bright-line stars and variable stars which are most numerous in its plane. When this work was begun our knowledge was so incomplete that a continuous chain of chemical facts was out of the question; but, thanks to the advances to which I have now to refer, we can deal with this cosmical evolution from a chemical standpoint, and what we have to do to-night is to consider the result of this inquiry.

I may begin by saying that now the gaps in our knowledge have been filled up, we find ourselves in the presence of a chemical evolution which is really majestic in its simplicity. Such a chemical evolution was suggested by me many years ago now, to explain the few stellar facts with which we were then familiar; but I do not propose to take up your time with any historical allusions; I must point out, however, that we to-night are in a very much better condition to consider this problem than we have ever been before, because at the present moment we have tens of thousands, I might almost say hundreds of thousands, of coordinated facts to go upon.

The first point I have to refer to is this: we have brought the sun and the stars together into line in all matters relating to the discussion of the effects of higher temperatures. The photographs taken during the recent solar eclipses show that when we deal with the hottest part of the sun that we can get at, which is hotter than that part of the sun which produces the well-known absorption spectrum marked by the so-called Fraunhofer lines, we are not in an unknown territory at all, but are brought face to face with similar phenomena to those in the atmospheres of stars which are hotter than our sun. The bright-line spectrum of the sun's chromosphere seen during an eclipse shows us the effects produced by heat in the hottest part of the sun that we can reach; these we can compare with the dark lines of a star which contains absorption lines very different from those represented by the Fraunhofer lines, and we find that they correspond almost line for line.

In this manner then we have an opportunity of correlating all the facts which have been obtained during the last, let us say, thirty years, in relation to the sun, with more recent facts than have been gathered with regard to the stars. In this work we were, by hypothesis, watching the effects of dissociation as the temperature rose higher and higher; but if we change our point of view, if we consider the phenomena no longer from the point of view of dissociation but from that of evolution, we find at once that the facts recently garnered carry us very far indeed along a new line of thought.

Let me give you an idea of what I mean. Let us deal, for instance, with well-known chemical compounds, say chloride of sodium, that is common salt, and oxide of iron, that is iron-rust. We have no difficulty in recognising the fact that chlorine and sodium in one case and oxygen and iron in the other must have existed before their compounds, common salt and iron rust, could be formed or associated. Water is split into hydrogen and oxygen at a high temperature, so that there is a temperature above which the two gases would remain in contact but uncombined; when the temperature falls water is produced. Dissociation, therefore, in all its stages must reveal to us the forms the coming together of which has produced the thing dissociated or broken up by heat. If this be so, the final products of dissociation or breaking up by heat must be the earliest chemical forms. Hence we must regard the chemical substances which visibly exist alone in the hottest stars as representing the earliest evolutionary forms. That, I think, is pretty obvious.

If we were only dealing with ordinary chemical forms it might be objected that it was only a question of *seeing;* that all chemical substances were really *present* in the reversing layer, that is the part of the atmosphere of the stars which we can study, but some only made their appearance; but I shall show later that the orderly progression includes lines of substances which we cannot see at all and others which we can only see at the highest possible temperatures in our laboratories.

Two or three times over I have used the words "evolution" and "evolutionary forms." What do these words really mean?

Perhaps I can give an idea of this by referring to another line of work altogether in which the word is frequently used and thoroughly understood. It is important that I should do this for another reason, which you will gather later. That line of work has to do, not with inanimate forms, like the chemical elements and the stars, but with living things, with so-called organisms. Some of my audience to-night doubtless remember Huxley's lectures here in 1860 On the Relations of Man to the Lower Animals, and most of you know that what we now recognise as one of the greatest triumphs of the century just ending was the determination of the truth of a so-called "organic evolution" in which we have, I suppose, the most profound revolution in modern thought which the world has seen.

That evolution tells us that each kind of plant and animal was not specially created, but that successive changes of form were brought about by natural causes, and that the march of these forms was from the more simple to the more complex. Organic evolution, in fact, may be defined as the production of new organic forms from others more or less unlike themselves; so that all the present plants and animals are the descendants, through a long series of modifications or transformations, or both, of a limited number of an ancient simpler type. We must not suppose that this change has gone on as if things were simply mounting a ladder; the truth seems to be that we have to deal with a sort of tree with a common root and two main trunks representing animal and vegetable life; each of these is divided into a few main branches, these into a multitude of branchlets, and these into smaller groups of twigs.

This new view represents to us the evolution of the sum of living beings; shows that all kinds of animals and plants have come into existence by the growth and modification of primordial germs. Now I want just to say that this is no new idea, it is the demonstration which is new to us in our present century and generation; we have really to go back to the seventeenth century, if indeed we must not go as far back as Aristotle, for the first germs of it; but with regard to the history, however, I have no time to deal with it. There are two or three points, however, to be considered in regard to this evolution. The individual organic forms need not continuously advance; all that is required is that there shall be a general advance—an advance like that of our modern civilisation—while some individual tribes or nations, as we know, stand still, or become even degenerate. With

[1] A Lecture to Working Men, delivered at the Museum of Practical Geology on Monday, April 24, by Sir Norman Lockyer, K.C.B.

this reservation; the first forms were the simplest. It may be that as yet we know really very little of the dawn of geological history; that the fossiliferous rocks are nowhere near the real base. This conclusion has been derived by Prof. Poulton[1] from the complexity of the forms met with in them; still we find that we have not to deal with such a vast promiscuous association of plants and animals of lowest and highest organisation as we know to-day; we deal relatively only with the simplest. The story both with regard to plants and animals is alike in this respect.

Let me deal with the plants first. The first were aquatic—that is to say, they lived in and on the waters. So far as we know, the first plant life was akin to that of the algæ which include our modern seaweed, moss-like plants followed them, and then ferns, and it is only very much later that the forms we know as seed plants with gaily coloured flowers living on the land made their appearance. The general trend of change amongst the plants has been in the direction of a land vegetation as opposed to one merely in or on the surface of the waters, and some present seaweeds exhibit the initial simplicity of plant-structure which characterised the beginning of vegetable life, while the seed plants I have mentioned are of comparatively late development; but we still have our seaweed; so that with all the change in some directions some forms like the earlier survive.

After this explanation, relating to work in an apparently different direction, you will have no difficulty in understanding the meaning I attach to the word "evolution" in relation to stars and the chemical elements which visibly exist in them, so far as the history of plant change is concerned; but we are not limited to plant life. The same conceptions apply to animal life, and it is important for my subject that I should refer to that also. What do we find there? We are brought face to face with the same progression from simple to complex forms. This is best studied by a reference to the geological record

Stratigraphical geology is neither more nor less than the anatomy of the earth,[2] and the history of the succession of the formations is the history of a succession of such anatomies; or corresponds with development as distinct from generation. In stratigraphical geology, as can be gathered from any book on geology, we find the names of certain beds which contain certain different forms of animal and vegetable life. We begin with the Laurentian and Algonkian and then pass to the Cambrian, then to the Ordovician, the Silurian and Devonian, and so on through a long list of beds and geological strata until we come eventually to the Recent, that is to say, the condition of things which is going on nowadays on the surface of the earth. And if we prefer to map those many different beds into more generic groupings, we begin with the Primary or Palæozoic, we pass on to the Secondary or Mesozoic, and then we finally reach the Tertiary or Cainozoic. The deposition of these beds and of the animal life which has been going on continuously on the surface while those beds have been deposited gives us the various changes and developments which have taken place with regard to animal forms. It is worth while to go a little into details and to indicate the changes in these forms which have taken place, in the most general way. Beginning with the Lower Cambrian, we find that the animal forms were represented by Invertebrata such as Sponges, Corals, Echinoderms, Brachiopods, Mollusca, Crustacea and many early Trilobites; not to mention true Fucoids and other lowly plant-remains. When we come to the Silurian, we find a large accession of the above forms, especially of Corals, Crinoids, and Giant Crustaceans (such as *Pterygotus*) and armoured animals (Ostracodermi) without a lower jaw, or paired fins; the beginnings of Vertebrate life, not yet fully evolved, and one lowly organised group of armoured fishes named *Cyathaspis* (without bone cells in their shelly-shield). Here, too, we meet with the first Air-breathers; the wing of a Cockroach, and several entire and undoubted Scorpions! Thus in addition we get vertebrates as opposed to invertebrates, and the first traces of the fishes. In the advance to the Devonian the fishes (associated with giant Crustacea) predominate; it has been called the age of fishes. In the next series, the Carboniferous, we find the first certain traces of amphibians, of which the early existence is like that of a fish: a state of things illustrated by the frog, which the majority of us in our early days have, I am sure, studied as a tadpole in its early stages; and some of these amphibians still retain fish-like characters. It is not until we arrive at the Permian that the true reptiles are met with, but in the next great series, the Triassic, we meet with a remarkable evolutionary group of Reptiles, the Theriodontia, or beast-toothed animals, because (unique among reptiles) they possess a dentition like a dog or a lion, with incisors, canines and cheek-teeth; the precursors doubtless of the succeeding Mammalian type. We pass easily thus from the reptiles to mammals which are related to them; for instance, the ornithorhynchus and the echidna are both Australian mammals which bring forth their young within the egg as do the reptiles. Well, after that we begin to deal with birds. The early birds were strikingly reptilian in some of their characters; and the pterodactyle, which many of you may have seen remains of in different museums, was really a winged reptile and not a bird. From that we gather that mammals and birds are variants of reptiles. When we progress from the Jurassic to the Recent, we find man making his appearance as a direct descendant of all those early forms. There is not much new in this. This, as I have said, is what Huxley largely demonstrated in this theatre thirty-nine years ago in a previous course of these Lectures to Working Men.

When we come to study the life-history of the various forms brought before us by the geological strata, we find it to vary considerably, a fact indicated by the presence or absence of the different genera in the various strata. We find that the trilobites, for instance, only appear in the very early geological formations: there is no trace of them in the recent, but if we take the annelids we find that they are continuous from the earliest to the latest formations; we still have our worms. Again we find that certain other organic forms made their appearance very low down in the time scale, forms which were not represented at all in the earlier Cambrian and Silurian, and that some of these are continuous to the present day. Let us take the story of the fishes. A great many fishes made their appearance at the Devonian stage, there were few in the Silurian; some of these stopped there, whereas others have been continued from the Devonian times to our own. Take, for instance, the Australian mudfish *Ceratodus*; to judge from the teeth this fish might well have lived on unchanged from late Palæozoic times until the present day! We see there is a tremendous variation of possible life-range, so to speak, with regard to these different forms, and the plant record, although necessarily more imperfect than the animal on account of the nature of the organism, tells the same story in its fragmentary evidence. In that way, then, the geologist has been able to bring before us the continuity of life in various forms from the most ancient geological strata to the most recent. The record may be incomplete, but is complete enough for my purpose. But that is not the only evidence of evolution to which I can refer.

The teachings of embryology confirm the argument based upon the study of geology, and suggest that the life-history of the earth is reproduced in the life-history of individuals. The processes of organic growth or em-

[1] Presidential Address, Section D, British Association Meeting at Liverpool, 1896.
[2] Huxley, *Q. J. G. S.*, xxv. p. xliii.

bryonic development present a remarkable uniformity throughout the whole of the zoological series; and although knowledge is still limited, some authorities hold that there is the closest possible connection between the development of the individual and the development of the whole series of animal life. There are others, however, who do not regard the argument derived from embryology as a very convincing one. However this may be, if we study the embryos of the tortoise, fowl, dog and man, we find that there is a wonderful similarity between them at a certain stage. At a further stage of development the similarity is still borne out. This does not mean that a vertebrate animal during its development first of all becomes a tortoise, and then the various animals which are represented by these embryos; it simply means that they are all related inasmuch as there is continuity.

After these references to plants and animals it should be clear what organic evolution really is, and therefore what evolution is generally. I wish next to bring before you some considerations having relation to the stratigraphical record.

The question for us now is—Is there any equivalent to this in the inorganic world? or, to put it in another way, in those facts which have been revealed to us by the presence of the various chemical forms in the stellar strata represented by stars of varying temperatures? That is the question.

When I referred in my last course of Lectures here to cosmical evolution, I said that there we dealt with a continuity of effects accompanied by considerable changes of temperature; from the gradual coming together of meteoritic swarms until eventually we had a mass of matter cold and dark in space. The various stars which represent the different changes have been got out and have, in fact, been arranged along a so-called temperature curve. As we ascend one branch of this curve the stars get gradually hotter and hotter till ultimately at the top we find the hottest stars that we know of. Then on the descending branch are represented the cooling bodies, and finally they come down in temperature until we reach that of a dark world like the companion of Sirius, of our own moon, and the planet in which we dwell.

*We can now deal with all these bodies in relation to their chemistry.* We find that in the hottest stars we get a very small number of chemical elements; as we come down from the hottest star to the cooler ones the number of spectral lines increases, and with the number of lines of course the number of chemical elements. I will only refer to the known substances, it looks as if at present we have still many unknowns to battle with. In the hottest stars of all, we deal with a form of hydrogen which we do not know anything about here (but which we suppose to be due to the presence of a very high temperature), hydrogen as we know it, the cleveite gases, and magnesium and calcium in forms which are difficult to get here; we think we get them by using the highest temperatures available in our laboratories. In the stars of the next lower temperature we find the existence of these things continued in addition to the introduction of oxygen, nitrogen and carbon. In the next cooler stars we get silicium added; in the next we get the forms of iron, titanium, copper and manganese which we can produce at the very highest temperatures in our laboratories; and it is only when we come to stars much cooler that we find the ordinary indications of iron, calcium and manganese and other metals. All these, therefore, seem to be forms produced by the running down of temperature. As certain new forms are introduced at each stage, so certain old forms disappear. In order to connect this work with the stratigraphical work, to which I have referred, I have recently tried to define these various star-stages by means of their chemical forms which they reveal to us; so that we may treat these stellar strata, so to speak, as the equivalent of the geological strata to which I have already called your attention.

From the hottest to the coldest stars I have found ten groups so distinct from each other chemically that they require to be dealt with separately as completely as do the Cambrian and the Silurian formations. Imitating the geologist, I have given the following names to these groups or genera beginning with the hottest, that is the oldest dealing with the running down of temperature:—Argonian, Alnitamian, Achernian, Algolian, Markabian [a "break in strata"], Sirian, Procyonian, Arcturian (solar), Piscian.

I have gone further, and defined the chemical nature of these stellar genera as the biologist defines the nature of any of his organic genera; we can say, for instance, that the Achernian stars contain chiefly hydrogen, nitrogen, oxygen and carbon, and to a certain less extent they contain proto-magnesium, proto-calcium, silicium and sodium,[1] and possibly chlorine and lithium; so that at last, by means of this recent development of spectrum analysis, we have been able really to do for the various stars what the biologist a good many years ago did for the geological strata.

Now, considering this inorganic evolution from the chemical point of view, there are several matters which merit consideration. We shall not get much help by thinking along several obvious lines, for the reason that in the stars we are dealing with transcendental temperatures; for instance, we must not make too much of the difference between gases and solids, because, at high temperatures all the chemical elements known to us as solids are just as gaseous as the gases themselves; that is to say, they exist as gases; at a high temperature, everything, of course, will put on the nature of gas. Those substances with the lowest melting points, such as lithium and sodium, will, of course, under our present conditions put on the gaseous condition very much more readily than other substances like iron and platinum, but those are considerations which need not be taken into account in relation to very high stellar temperatures; of course, there would be no solids at a temperature of 10,000° C.

Then with regard to metals and non-metals. Here again we really are not greatly helped by this distinction. The general conception of a metal is that it is a solid, and that therefore a thing that is not a solid is not a metal; but the chemical evidence for the metallic nature of hydrogen has been enlarged upon by several very distinguished chemists. With regard to non-metals, there are certainly very many. Carbon is supposed to be a non-metal, and it is remarkable that, so far as the stellar evidence which I have brought before you has gone, carbon seems to be the only certain representative of that group. I want to point out specially that the table of the chemical definitions of the various stellar genera which I show you, which contains nothing but hard facts, is perhaps, like the geological record, more important on account of what it indicates as to the presence of the chemical elements in the stars than it is for what it omits.

There are a great many reasons why some of the substances which may exist in these stars should not make their appearance. I wish to enlarge upon the fact that, seeing the very small range of our photographs of stellar spectra, and seeing that it does not at all follow that the particular crucial lines of the various chemical substances will reveal themselves in that particular part of the spectrum which we can photograph, that the negative evidence is of very much less importance than the positive evidence. I think it is very likely, for instance, that we must add lithium to

[1] Campbell, "Astronomy and Astro-physics," 1894, xiii. p. 395.

the substances which we find in the table, we must certainly add sodium, and also aluminium, and chlorine possibly, but about sulphur at present I have no certain knowledge; you will see the reason for these references later on. At all events, we can with the greatest confidence point out the remarkable absence of substances of high atomic weights, and the extraordinary thing that the metals magnesium and calcium undoubtedly began their existence in the hottest stars long before, apparently, there is any obvious trace of many of the other metals which a chemist would certainly have been looking out for.

In relation to this new work, the first point to make is that the chemical forms we see in the hottest stars are amongst the simplest. What is the justification for this statement? Well, there are two reasons. The chemist will acknowledge that if there be such a thing as chemical evolution, an element of low atomic weight is simpler, that is, less massive, than an element of high atomic weight. If we rely upon spectrum analysis we can say, when dealing with the question of "series," about which I hope to say something in my next lecture, that the elements which have the smallest number of "series" are in all probability simpler than those which have a large number, and this is still truer when we find that all the lines in the spectrum of a substance can be included in those rhythmical series, as happens in the case of the cleveite gases. So that the first stage of inorganic evolution, if there has been such an evolution, is certainly a stage of simplest forms as in organic evolution.

The next point is that the astronomical record, studied from the evolution point of view, is in other ways on all-fours with the geological record. We get the same changes of forms, I may say that we get the sudden breaks in forms, disappearances of old accompanied by appearances of new forms, and with this we get, whether we consider the atomic weight point of view or the series point of view, a growth of complexity.

The geological story is exactly reproduced. Now, here it is obvious that a very important point comes in. In inorganic evolution we are dealing with a great running down of temperature; how tremendous, no man can say. We know the temperature of our earth, but we do not know, and we can not define, the temperatures of the hottest stars. So that how great the temperature of the earth may once have been, supposing it to be represented by the present temperature of the hottest star, no man knows anything with certainty.

With regard to organic evolution, however, which has to do with the plant world and the animal world, there can have been no such running down of temperature at all. The temperature must have been practically constant. Please bear that in mind, because I shall have to refer to it later on.

It is proper that I should say that just as the work of Darwin in the nineteenth century was foreshadowed by seventeenth century suggestions, so the stellar demonstration which I have brought before you to-night has been preceded by hypotheses distinctly in the same direction. The first stage of chemistry, as you know, was alchemy. Alchemy concerned itself with transmutations, but it was found very early that the real function of the later science of chemistry was to study *simplifications*, and, of course, to do this to the utmost we want precisely those enormous differences in temperature which it appears the stars alone place at our disposal.

With regard to the general question of inorganic evolution, the first idea was thrown out in the year 1815 by Prout, who, in consequence of the low atomic weight of hydrogen, suggested that that gas was really the primary element, and that all the others, defined by their different atomic weights, were really aggregations of hydrogen, the complexity of the aggregation being determined by the atomic weight; that is to say, the element with an atomic weight of twenty contained twenty hydrogen units; with an atomic weight of forty it contained forty, and so on. The reply to that was that very minute work showed that the chemical elements, when they were properly purified and examined with the greatest care, did not give exactly whole numbers representing their atomic weights. They were so and so plus a decimal, which might be very near the zero point, or half-way between, and that was supposed to be a crushing answer to Prout's view. The next view, which included the same idea—that is to say, a physical connection between these different things as opposed to the view that they were manufactured articles, special creations, each without any relation whatever to the other, was suggested by Döbereiner in 1817, and the idea was expanded by Pettenkofer in 1850. Both pointed out that there were groups of three elements, such as lithium, sodium, and potassium, numerically connected; that is, their atomic weights being 7, 23, and 39, the central atomic weight was exactly the mean of the other two, $7 + 39 = 46$, divided by 2, we get 23. Another way, however, of showing that is that $7 + 16 = 23$, and $23 + 16 = 39$; the latter method suggests a possible addition of something with an atomic weight of 16.

In 1862 de Chancourtois came to the conclusion that the relations between the properties of the various chemical elements were really simple geometrical relations. That, you see, is a much broader view. It is not till 1864 that we come to the so-called "periodic law," which was first suggested by Newlands, and elaborated by Mendeléeff in 1869. According to this law, the chemical and physical properties of the elements are periodic functions of their atomic weights. Lothar Meyer afterwards went into this matter, and obtained some very interesting results from the point of view of atomic volumes. He showed that if we plot the atomic volumes of the different elements, arranged according to their atomic weights from left to right, there is a certain periodicity in the apices of the curve indicating the highest atomic volumes.

So far there was no reference to the action of temperature in relation to this, but in 1873 I suggested that we must have a fall of temperature in stars, and that the greater complexity in the spectra of certain stars was probably due to this fall of temperature. This idea was ultimately utilised by Sir William Crookes in an interesting variation of the periodic law, in which he assumes that temperature plays a part in bringing about the changes in the characters of the elements. Brodie, in 1880, came to the conclusion that the elements were certainly not elementary, because in what he called a "chemical calculus" he had to assume that certain substances, supposed to be elements, were really not so; and he then threw out the very pregnant idea that possibly in some of the hotter stars some of these elements which he predicted might be found. Nine years afterwards, Rydberg, one of the most industrious investigators of the question of "series" to which I have referred, stated that most of the phenomena of series could be explained by supposing that hydrogen was really the initial element, and that the other substances were really compounds of hydrogen; so that you observe he came back to Prout's first view in 1815.

All these ideas imply a continuous action, and suggest that there was some original stuff which was continuously formed into something more complex as time went on. That is to say, that the existence of our chemical elements as we know them does not depend upon their having been separately manufactured, but that they are the result of the working of a general law, as in the case of plants and animals.

You see at once that the stellar facts which have already been brought before you are entirely in harmony with the highest chemical thought, and indeed establish

the correctness of its major contention. We may be said to pass from chemical speculation to a solid chain of facts, which doubtless will be strengthened and lengthened as time goes on. In all these changes we seem to be in the presence of a series of what chemists call polymerisations, that is, roughly, a series of doublings. The greater complexities may also have been brought about by the union of different substances. In either case, as temperature is reduced, we get a possibility of combinations which was not present before; so that more and more complex forms are produced.

That brings us to a possibility of considering the processes of inorganic evolution in relation to those of organic evolution. I have already referred to the fundamental difference in the conditions. We had a running down of temperature which no one could define in the case of the stars; in the case of the organic evolution going on under our present conditions, we cannot be very much removed from the temperature conditions of the Cambrian formations. That is a point which I have made before, and it is important to insist upon it; clearly there cannot have been any very great change of temperature during the whole cycle of organic life. Previous to it we have found complexity brought about by doublings and combinations, the result being, as I have already mentioned, more complex forms. Of course, at the dawn of organic life on the surface of the earth there may have been residua of the earlier chemical forms; that is to say, not all the elements which we found in the hottest stars had combined to form the substances of which the earth was composed. However this may be, the work of organic evolution, unlike that of inorganic evolution, must have been done under widely different temperature conditions, but the result has been the same; it has since provided us with another succession of forms getting more complex as time has gone on, and there is still a residuum of early forms. We are led then to the conclusion that life in its various forms on this planet, now acknowledged to be the work of evolution, was an appendix, as it were, to the work of inorganic evolution carried on in a perfectly different way. Although the way was different, still nature is so parsimonious in her methods—she never does a thing in two ways that can be as well done in one—that I have no doubt that when these matters come to be considered, as they are bound to be considered with the progress of our knowledge, we shall find a great number of parallels; but I am not looking for these parallels now. What I wish to drive at is a chemical point of view which I think of some importance in relation to what has gone before; it is a point which I wish to make depending upon the existence of those elements which make their appearance in the hottest stars. In inorganic forms, in those represented to us in the hottest stars and the stars of gradually lower temperature, we have forms produced by a junction of like or unlike forms. Very good; but the more of these junctions the more the early forms must have disappeared, unless we may take it that they may have been made occasionally to reappear by the destruction of the later forms: that is a point to bear in mind. If the simpler forms must go on doubling to provide the more advanced forms, then if all the simpler forms are so used up there will be none left, and the only chance of getting the simpler forms again is to destroy something which had been previously made; and we can quite understand, of course, that there were many conditions of this destruction possible at the time when the crust of the earth was being formed. But however that may be, the gaseous elements with the non-gaseous elements first formed, would be the chief chemical substances on the surface and over it. Now the substances over the crust, of course, would be the gases, oxygen, hydrogen, nitrogen, and from the stars we can suggest carbon combined with them; that is to say, hydrocarbons, carbonic acid, and so on. On the surface, whether the surface be one of land or water, we should expect, in addition to the low melting point metals lithium and sodium, those two metals which we know existed in the hottest stars long before the others, magnesium and calcium. I have told you that lithium probably and sodium certainly exist in some of the relatively hot stars; the evidence also suggests sulphur, and this is rendered more probable because of the simplicity of its spectrum-series. Now these are very remarkable associations, and seem far away from ordinary chemical considerations, but they are the most important substances in sea water.

*Constituents of Sea Water.*

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|---|---|
| Chloride of sodium ... ... ... | 77·75 |
| ,, magnesium ... ... ... | 10·87 |
| Sulphate of ,, ... ... ... | 4·73 |
| ,, lime ... ... ... ... | 3·60 |
| ,, potash ... ... ... ... | 2·46 |
| Bromide of magnesium ... ... ... | 0·21 |
| Carbonate of lime ... ... ... ... | 0·34 |

The most easily thinkable evolution under these circumstances would be that of organisms built up of these chemical forms, chiefly because they would represent the more mobile or the more plastic materials. You would not expect evolution to have begun in iron, you would have expected it to have begun in something which was the most mobile and the most plastic. The available matter then for this evolution would be those gases plus those metals and those non-metals to which I have referred. Now, mark this. Suppose you have this evolution; if the forms so composed were to be multiplied indefinitely, the available material would be used up and organic evolution would be brought just as certainly to a dead-lock as the inorganic evolution was brought to a dead-lock when there was no possibility of any considerable reduction of temperature. We should expect a tendency to growth among the organic molecules, I dare not call it an inherited tendency, but I feel almost inclined to do so, having the growth of crystals in mind. Now, suppose that after you have got these new organic forms, the results instead of being stable were emphatically unstable, and still better, suppose you could induce a dissolution or the destruction of parts or wholes, progress would always continue to be possible, and indeed it might be accelerated.[1]

The new organic molecules would ultimately not have the first user of the chemical forms left available by the inorganic evolution, but they would have the user of the gases and other substances produced by the dissolution of their predecessors. They would be shoddy chemical forms, it is true, but shoddy forms would be better than none. Under these circumstances and in this way, the organic kingdom would be allowed to go on; in other words, the dissolution of parts or wholes of the new organisms would not merely be an advantage to the race, but might even be an essential condition for its continuance.

It therefore looks very much as if we can really go

[1] My friend and colleague, Prof. Howes, has called my attention in this connection to Prof. Weismann's views ("Weismann on Heredity," vol. i. p. 112), who seems to have arrived at somewhat similar conclusions, though by a vastly different road. He says, in his "Essay on Life and Death," "In my opinion life became limited in its duration not because it was contrary to its very nature to be unlimited, but because an unlimited persistence of the individual would be a luxury without a purpose."

The general view I have put forward, however, suggests that perhaps it was not so much a question of *luxury* for the living as one of *necessity* in order that others might live; it was a case of *mors janua vitae*.

The whole question turns upon the presence or absence, in all regions, of an excess of the early chemical forms ready to be used up *in all necessary proportions*. Hence it may turn out that the difficulty was much greater for land- than for sea-forms, that is, that dissolution of parts or wholes of land-forms proceeded with the greater rapidity. It is a question of the possibility of continuous assimilation (see Dantec, "La Sexualité," p. 11), and the word "parts" which I have used refers to the somatic cells, and not to the "immortal" part of living organisms.

back as far as these very early stages of life on our planet to apply those lines of Tennyson :—

> "So careful of the type she seems,
> So careless of the single life."

We have arrived, then, at a condition in which the same material may be worked up over and over again; in this way ultimately higher forms might be produced. Now, if to this dissolution, as a means of giving us new material, we add reproduction, then we can go a stage very much further. If we take bi-partition, which was the first method of multiplication, as we know both in the vegetable and animal world, we have a multiplication of forms by halving instead of the inorganic multiplication of forms by doubling, then we can have a very much increased rate of advance.

These then, roughly, are the conclusions as to an organic evolution which are suggested by the stellar evidence as to inorganic evolution, and the collocation of the simplest forms noted in the hottest stars.

Let us turn finally to the facts. Biologists, as I have said before, are very much more happy than astronomers and chemists, because they can see their units. A chemist professes to believe in nothing which he does not get in a bottle, although I have never yet seen the chemist who was ever happy enough to bottle an atom or a molecule as such ; but the superstition still remains with them, and they profess to believe in nothing that they cannot see. Now, the organic cell is the unit of the biologist, which is itself a congeries of subordinate entities, as a molecule is made up of its elementary atoms, manifesting the properties common to living matter in all its forms.

The characteristic general feature of the vegetable activity of the plant forms is their feeding upon gases and liquids, including sea-water. The progress of research greatly strengthens the view that there was a common life plasm, out of which both the vegetable and the animal kingdoms have developed. Be that as it may, you see the vegetable grows upon these chemical forms to which I have referred, and the animal feeds either upon the plant or upon other animals which have in their turn fed upon plants ; so that there we get the real chemical structure of the protoplasm, of the real life unit, in our organic evolution.

The last question, then, that I have to touch upon is this. Is there any chemical relation between the chemical composition of the organic cell and the reversing layers of the hottest stars—the reversing layer being that part of a star's anatomy by which we define the different genera ?

When we come to consider the chemical composition of this cell we find it consists of one or more forms of a complex compound of carbon, hydrogen, oxygen, nitrogen, with water, called protein ; and protoplasm, of which you have all heard, the common basis of vegetable and animal life, is thus composed. This substance is liable to waste and disintegration by oxidation, and there may be a concomitant reintegration of it by the assimilation of new matter.

The marvellous molecular complexity of the so-called simple cell may be gathered from the following formulæ for hæmoglobin :

| | | | | | | |
|---|---|---|---|---|---|---|
| Man ... | C 600 | H 960 | N 154 | Fe 1 | S 3 | O 179 |
| Horse ... | C 712 | H 1130 | N 214 | Fe 1 | S 2 | O 245.[1] |

Various different percentage compositions have been given of this protoplasm, but I really need not refer you to them. It is more important to consider the other chemical substances which go to form it, for there are others beside which it is of interest to study from our stellar point of view. I quote from Mr. Sheridan Lea.[2]

"Proteids ordinarily leave on ignition a variable quantity of ash. In the case of egg-albumin the principal constituents of the ash are CHLORIDES of SODIUM and potassium, the latter exceeding the former in amount. The remainder consists of SODIUM and potassium, in combination with phosphoric, sulphuric and CARBONIC acids, and very small quantities of CALCIUM, MAGNESIUM and iron, in union with the same acids. There may be also a trace of SILICA."

My point is that the more one inquires into the chemistry of these things the more we come back to our stellar point of view and to the fact that, taking the simplicity of chemical form as determined by the appearance of these different chemical substances in the hottest stars as opposed to the cooler ones, and in relation to the "series" of spectra which they produce, we come to the conclusion that the first organic life was an interaction somehow or other between the undoubted earliest chemical forms. Not only have we hydrogen, oxygen and nitrogen among the gases common to the organic cell and the hottest stars, but those substances in addition which I have indicated by capitals.

Surely we have here, I think, thanks to some of the recent advances made by spectrum analysis, a quite new bond between man and the stars.

We shall consider in the next lecture the simplicity of chemical forms as evidenced, not by atomic weight, but by the study of spectrum-series, to which I have already made two or three references.

[1] "Verworn," p. 104.
[2] "The Chemical Bases of the Animal Body," p. 5.

## *THE BERLIN TUBERCULOSIS CONGRESS* (1899).

THE Congress, which has just brought its proceedings to a close, was not, as has been frequently stated in the medical and lay press, an International Congress ; it was a German Congress to which foreign delegates and communications were invited. The mass of communications were made in German, this being the official language of the Congress ; a few, some half-dozen, in English and French. The necessity, or at any rate advisability, of discoursing in German, may account for the very meagre manner in which English medicine was represented either privately or officially. It seemed somewhat anomalous that the staff of only one London consumption hospital (the North London) was represented at the Congress. Further, the English doctors practising at foreign health resorts, who probably have unrivalled opportunities for observing the different phases of consumption, and the influence of treatment upon them amongst better class patients, were for the most part conspicuous by their absence. This nonchalance is to be regretted, especially as the hygienic treatment of phthisis, a relatively, at any rate in its systematic form, new development, occupied some 50 per cent. of the whole time of the Congress.

The enormous amount of material at the disposal of the Committee was classified in two ways. All papers were in the first instance denominated as lectures ("Referate"), or discussion communications. For the former twenty minutes was allowed, for the latter ten. The subject-matter was divided into five Sections. I. Extent and Spread of Tuberculosis. II. Aetiology. III. Prophylaxis. IV. Treatment. V. Sanatorium Treatment.

Section I.—Dr. Bollingen (Munich) read a paper upon tuberculosis amongst domestic animals, and its relationship to tubercular disease in man. Amongst many important points, the lecturer emphasised the importance of milk as a source of tubercular infection to men, directly and indirectly. Indirectly in the sense that tuberculosis is very common amongst pigs, who get infected in considerable numbers from being fed with the milk of tuberculous cows. Dr. Krieger (Strassburg) discussed the re-

lationship of external surroundings to the spread of tubercular disease. The author pointed out the unsatisfactory nature of statistics upon this subject, owing to the complexity of apparently simple factors. Constant attendance upon phthisical patients in badly ventilated rooms, and certain occupations giving rise to irritation of respiratory tract from dust, metallic or otherwise, were however, according to the lecturer, potent factors in the spread of tuberculosis. Papers followed upon tubercular disease among various employés, notably knife and sword makers, bookbinders, compositors, and cigar makers.

Section II.—Aetiology.—This Section was opened by Prof. Flügge (Breslau), who read a well-appreciated paper upon the relation of the tubercle bacillus to tuberculosis. Recent work has not in this connection modified to any extent the dicta originally enunciated by Koch. The tubercle bacillus is the immediate cause of tuberculosis, and arises in practically all cases from a tuberculous animal. Its parasitic nature is obligatory, *i.e.* except in the case of artificial cultures the bacillus cannot develop outside the animal organism. By means of artificial cultures it is possible to modify the tubercle bacillus in certain ways, notably with regard to its morphological character, and its virulence. Prof. C. Frankel (Halle) discoursed eloquently upon the nature and *modus operandi* of tubercular infection. He pointed out that outside the animal body tubercle bacilli die in from six to seven months, the important factors in killing them being light, and the fact that they lose their water by evaporation, and with it their life. As a result of this it is, as a rule, only the immediate neighbourhood of the patient, from 1 to 1½ metre, that is infective. Infection usually takes place through the infected person inhaling fresh and moist tubercle bacilli which ("infected drops") have been ejected usually during a coughing fit, also by the inhalation of dust contaminated with dried sputum. He further pointed out that man was relatively unsusceptible to tubercular infection, and that, as a rule, it was only by repeated and continued inhalation, &c., of tubercle bacilli that infection occurred.

A subject of great interest to physicians was considered at some length by Prof. Pfeiffer (Berlin), viz. "mixed infection." Consumption, as we know it, is rarely due simply to the tubercle bacillus, but to the superadded action of other infective organisms. As many as twenty-four different varieties of bacilli have been obtained from the sputum of a phthisical patient. An important practical point brought out by the lecturer was that cases of mixed infection ought to be recognised in consumptive hospitals, and isolated, as they may be a source of danger to phthisical patients; that is, these latter may get a mixed infection superadded to their other troubles. Prof. Löffler read a short paper upon heredity, immunity and disposition in their relation to tuberculosis. Hereditary tuberculosis in the sense, for instance, of congenital syphilis, is unknown. In this disease hereditary influences probably play a relatively small part as such. Tuberculosis occurs in members of the same family, mostly because by living together the members infect each other. Prof. Löffler quoted one family as an instance of this. The father and mother, two daughters and seven sons, all died of phthisis. The family consisted of fifty-eight other members, not one of whom was tuberculous. The infection was entirely confined to the members of the family living together. The lecturer emphasised the fact that no natural immunity to tuberculosis exists. Dr. von Zander gave some aetiological statistics of tuberculosis. Out of 312 cases investigated, 116 were communicated from man to man; amongst these infection between sisters occurred the most often.

Section III.—Prophylaxis.—Dr. Roth (Potsdam) discussed certain rules for the prevention of tubercular infection. These mostly consisted of measures directed to the disposal of the sputum, and the use of a cloth in front of the mouth during coughing fits, to limit the area of "infective drop" dispersion. Prof. v. Leube (Wurzburg) considered the prophylactive methods against tuberculosis in hospitals. If measures such as those mentioned above are thoroughly carried out, tubercular patients need not be isolated from the general hospital inmates. Care should be taken by attendants and nurses especially in dusting rooms, when it would be advisable for them to have their mouth and nose protected by a mask.

All members of the Congress listened most attentively to a short paper, by Prof. Virchow, upon the prevention of tuberculosis in so far as concerns food. Prof. Virchow considered four articles of diet: (1) beef, (2) pork, (3) poultry, (4) milk. Of these he regarded milk as far the most important. He advised a more careful and systematic exclusion (under central control) of tubercular meat and cattle, and the rejection of milk from all cows which reacted to the tuberculin list. Even these measures the author described as palliative, the only curative measure being the killing of all animals that reacted to the tubercular list. In this connection, Dr. Schumburg (Hannover) gave the result of his researches as to whether ordinary butcher's meat contained tubercle bacilli. The result of twenty-four inoculations (intra-peritoneal) of guinea-pigs with the juice of twelve different meat samples, was that two animals died of purulent peritonitis, two greatly diminished in weight, the remaining twenty remained well. Dr. Baer (Berlin) discussed the much-vexed question of alcohol and tuberculosis. He concludes, upon apparently very insufficient grounds, that alcohol in the consumptive sanatoria should only be used as medicine under the most urgent circumstances. Dr. Ritter read a paper upon the protection of children from tuberculosis. An interesting communication upon the diminution in the total death-rate from consumption due to modern methods of treatment was made by Dr. Julius Lehmann (Copenhagen). Dr. Kuno Obermüller discussed some interesting investigations upon the presence of the tubercle bacillus in ordinary market milk and butter. He centrifugalised the milk, and injected less than ·5 cc. of the sediment into the peritoneal cavity of guinea-pigs. The milk was taken from a dairy which supplies Berlin with 80,000 litres daily. The result was that 30 per cent. of the injected animals died in from eleven to thirteen weeks of tuberculosis. The milk used was the best and most costly infant milk. According to the author, Berlin butter is also largely infected with virulent tubercle bacilli, which are quite distinct from the so-called butter bacillus. Dr. Hambleton, President of the Polytechnic Physical Development Society, was the author of a communication on the prevention of pulmonary tuberculosis. One of the most potent factors to this end is, according to the author, chest development, and he took this opportunity of bringing before the notice of the Congress the work of the Society in this direction. This method had, according to the author, been most successful in preventing and even arresting tuberculosis among the employés of trades having an injurious effect upon the respiratory organs.

F. W. Tunnicliffe.

## THE JUBILEE OF SIR GEORGE GABRIEL STOKES.

The celebrations in connection with the jubilee of Sir George Gabriel Stokes, who has occupied the Lucasian Chair of Mathematics at Cambridge University since 1849, begin this afternoon (Thursday) with the delivery by Prof. Cornu, of the École Polytechnique, Paris, of the Rede Lecture. Prof. Cornu has chosen as his subject, "The Wave Theory of Light and its Influence on Moder Physics."

This evening a banquet will be given by Pembroke College, at which many of the distinguished guests and older colleagues of Sir George will be entertained in the hall of the College, which he entered as a freshman in 1837. During the evening the University will entertain about one thousand visitors and residents at a conversazione in the Fitzwilliam Museum, an interesting feature of which will be the presentation by Lord Kelvin of two busts, executed by Mr. Hamo Thorneycroft, of Sir George Stokes—one to the University, and the other to Pembroke College.

On Friday at 11 a.m., in the Senate House, the addresses of congratulation will be presented to the Vice-Chancellor, and handed by him to Sir George Stokes. Some sixty-five different institutions from all parts of the world will be represented. At 7 o'clock the delegates and their hosts will be entertained at luncheon by the Vice-Chancellor at Downing College, and at 2.45 a second congregation will be held in the Senate House, at which the Chancellor, the Duke of Devonshire, will preside. At this congregation, the honorary degree of Sc.D. will be conferred on Profs. A. Cornu and J. G. Darboux of Paris, on Prof. A. A. Michelson of Chicago, on Prof. M. G. Mittag-Leffler of Stockholm, on Prof. G. H. Quincke of Heidelberg, and on Prof. W. Voigt of Göttingen. A gold medal struck in honour of the occasion will be presented to Sir George Stokes by the Chancellor, and replicas will be sent to all the Universities and learned societies who are represented at the Jubilee.

Later in the afternoon a garden party will be held in the grounds of Pembroke College, and in the evening the University will entertain the delegates and guests at a dinner given in the hall of Trinity College. The Chancellor will take the chair, and amongst other distinguished guests who have accepted invitations may be mentioned the Lord Lieutenant of Cambridgeshire, the Bishop of Ely, the President of the Royal Society, the Vice-Chancellors of the Universities of Oxford, Aberdeen, and London, the Earl of Rosse, Lord Kelvin, Lord Rayleigh, Lord Blythswood, the Provost of Trinity College, Dublin, Monsignor Molloy, and many others.

There will be a special meeting of the Cambridge Philosophical Society, at which some of the foreign members will, it is expected, read papers. This will probably take place on Monday, June 5. Many of the guests will leave Cambridge for London to take part in the anniversary celebrations of the Royal Institution.

## *NOTES.*

A MEETING for discussion will be held at the Royal Society on Thursday next, June 8. The subject to be discussed—preventive inoculation—will be introduced by M. Haffkine.

ARRANGEMENTS for the sixty-ninth annual meeting of the British Association at Dover, in September next, are making satisfactory progress. The local committees are actively at work, and in response to the appeal of the hospitality committees over 1500*l.* has already been subscribed. As previously announced, the president of the meeting will be Prof. Michael Foster, and the presidents of the various sections are to be:—Mathematical and physical science, Prof. J. H. Poynting; chemistry, Mr. Horace T. Brown; geology, Sir Archibald Geikie; zoology, Mr. Adam Sedgwick; geography, Sir John Murray, K.C.B.; economical science, Mr. Henry Higgs; mechanical science, Sir William H. White; anthropology, Mr. C. H. Read; physiology, Mr. J. N. Langley; botany, Sir George King, K.C.I.E. The first general meeting will be held at the Connaught Hall on Wednesday, September 13, at 8 p.m. precisely, when Prof. Michael Foster will deliver an address; on Thursday evening, September 14, at 8.30 p.m., there will be a soirée in the School of Art; on Friday evening, September 15, at 8.30 p.m., a discourse will be delivered by Prof. Charles Richet, on "La vibration nerveuse"; on Monday evening, September 18, at 8.30 p.m., a discourse will be delivered by Prof. Fleming, F.R.S., on "The Centenary of the Electric Current"; on Tuesday evening, September 19, at 8.30 p.m., there will be a soirée in the School of Art; on Wednesday, September 20, the concluding general meeting will be held at 2.30 p.m. Excursions to places of interest in the neighbourhood of Dover and to the continent will be made on Thursday, September 21. Members of the Association Française pour l'Avancement des Sciences will visit Dover on Saturday, September 16. Members of the British Association are invited to visit Boulogne on Thursday, September 21.

THE following naturalists have been elected foreign members of the Linnean Society:—M. Adrien Franchet of Paris, Prof. Emil Christian Hansen of Copenhagen, Dr. Seiitsiro Ikeno of the Imperial University, Tokyo; Prof. Eduard von Martens of Berlin, and Prof. Georg Ossian Sars of Christiania.

THE gold medal of the Linnean Society, which was presented at the anniversary meeting on May 24, has this year been awarded to Mr. John Gilbert Baker, of Kew, in recognition of his important contributions to botanical science. Amongst these may be mentioned his *Synopsis Filicum*, his monographs of the daffodils and roses, handbooks on the *Amaryllideae*, *Irideae*, *Bromeliceae*, and the fern allies; three volumes on the *Compositae* in Martins's "Flora Brasiliensis," and several papers on Malagasy botany, the Flora of Mauritius and the Seychelles, the Bulbous Flora of the Cape, and the *Leguminosae* of British India, "Flora of the English Lake Country," and numerous papers communicated to the *Journal* of the Linnean Society, the *Journal of Botany*, and other periodicals.

AT the annual meeting of the Victoria Institute, to be held on June 19, an address will be delivered by Sir Richard Temple.

THE anniversary meeting of the Royal Geographical Society will be held on Monday next, June 5. The Society's annual conversazione will be held in the Natural History Museum on Wednesday, June 7.

THERE will be no Friday evening discourse at the Royal Institution to-morrow (June 2), as Mr. H. G. Wells, who was to lecture on "The Discovery of the Future," is in too weak a state of health to do so.

AT the recent annual meeting of the American Academy of Art and Sciences, Mr. Alexander Agassiz was elected president of the Academy. The Rumford medal was awarded to Mr. Charles F. Brush, of Cleveland, for "the practical development of electrical arc lighting."

A REUTER telegram dated Helsingfors, May 26, says:—"The collected pieces of the aerolite which fell at Bjurholm some time ago have been sent here, and placed in the geological museum. The largest piece is said to weigh 206 Russian pounds, while all the parts together weigh 850 lbs."

DR. L. A. BAUER has resigned his position as assistant professor of mathematics and mathematical physics at the University of Cincinnati, in order to accept the position of chief of the newly-formed division of terrestrial magnetism of the United States Coast and Geodetic Survey. To this division has been assigned the magnetic survey of the United States and the countries under its jurisdiction, and the establishment of magnetic observatories. Dr. Bauer has also been appointed lecturer in

terrestrial magnetism at the Johns Hopkins University. The journal, *Terrestrial Magnetism and Atmospheric Electricity*, beginning with the June number, will be issued hereafter from the Johns Hopkins University Press, Dr. Bauer continuing as editor-in-chief.

ON the evening of May 13 a meeting of the New York Electrical Society was held at Madison Square Garden, where an Electrical Exhibition is now going on, to celebrate the centennial of the discovery of the electric battery by Alessandro Volta. Mr. Edison sent a letter expressing his admiration of Volta's investigations and researches, and associating himself with the fraternal messages which were sent to the Italian electrical society and to the Electrical Exhibition at Como, the birthplace of both Volta and the voltaic cell. The New York *Electrical Review* states the following message was cabled to the Italian Premier :—"The electricians of America, celebrating the Volta Centennial in New York, extend heartiest congratulations to the fellow-workers in Italy, and, in doing so, desire to express the hope that the work of such pioneers as Galvani, Volta, Pacinetti and Ferraris may be renewed and repeated by other members of the Italian race in the century which is now dawning. America owes a deep debt of gratitude to Italy for electrical discoveries, which have done so much to abridge distance and add to the welfare of mankind. Please communicate these sentiments to King Humbert in the name of the New York Electrical Society.—Gano S. Dunn, President."

THE Berlin correspondent of the *Times* states that the committee which is organising the German Antarctic expedition has decided that the expedition is to be composed of one ship only. The vessel, which is to be built entirely of wood, is to be laid down this autumn. The expedition is to be ready to start in the autumn of 1901, and is to be away two years altogether. After touching at the Cape, the expedition is to make for the Antarctic continent south of the Kerguelen Islands, and there establish a scientific station at some point suitable for wintering. A pack of Siberian dogs is to be taken, and dashes will be made on sledges towards the South Pole and the south magnetic pole. Meteorological observations will also be made from a captive balloon. After the breaking up of their winter quarters, the expedition will attempt to make as complete a survey as possible of the coast line of the Antarctic continent. As already announced in these columns, the leader of the expedition is to be Dr. von Drygalski, who conducted the German exploration of Greenland in the years 1891-93. The committee expresses great satisfaction that the English Antarctic expedition has at last been definitely decided on, and points out that the value of the two sets of meteorological observations will be greatly enhanced by their being carried on simultaneously.

AN Industrial Exhibition organised by the Artist Club was opened at the Crystal Palace on Tuesday by the Duke and Duchess of Connaught. The exhibition has been furnished by about one hundred leading British manufacturers, and the element of competition has been eliminated by only including one set of exhibits of any particular industry. Engineering appliances of various kinds are prominent. Railway and steamship interests are also well represented. Refrigerating processes employed in the Colonial meat trade are shown in operation. There is also an interesting display of printing machinery at work, and of type-setting by Linotype machines. Electricity figures in the exhibition, and a number of novel devices of various kinds are to be seen. As an example of quick work in photography, it is worth mention that the opening ceremony was photographed and projected upon the screen by the Biograph and Mutoscope Company before the Royal party left the Crystal Palace three hours later.

AT the annual general meeting of the Institution of Electrical Engineers, held on Thursday last, the announcement was made that the premiums for papers read during the session 1898-99 had been awarded by the Council as follows :—The "Institution Premium," value 25*l.*, to Mr. P. V. McMahon, for his paper on "Electric Locomotives in Practice, and Tractive Resistance in Tunnels, and Notes on Locomotive Design"; the "Paris Electrical Exhibition Premium," value raised to 20*l.*, to Mr. W. Duddell and Mr. E. W. Marchant, for their paper, "Experiments on Alternate Current Arcs by aid of Oscillographs"; two "Fahie Premiums," none having been awarded in 1898, of 10*l.* each, one to Prof. O. Lodge, F.R.S., and one to Mr. G. Marconi, for their papers entitled respectively "Improvements in Magnetic Space Telegraphy" and "Wireless Telegraphy"; two extra premiums of 10*l.* each, one to Mrs. Ayrton for her paper on "The Hissing of the Electric Arc," the other to Mr. J. Elton Young, for his paper on "Capacity Measurements of Long Submarine Cables"; the Senior "Students' Premium," value 10*l.*, to Mr. W. G. Royal-Dawson, student, for his paper on "Alternating Currents of very High Frequency"; the second "Students' Premium," increased in value to 10*l.*, to Messrs. M. R. Gardner and W. P. Hewgrave Graham, for their paper on "The Synchronising of Alternators"; the third "Students' Premium," value 5*l.*, to Mr. Leonard Wilson, student, for his paper on "The Effect of Governors on the Parallel Running of Alternators"; extra "Students' Premium," value 4*l.*, to Mr. L. R. Morshead, for his paper on "Enclosed Arc Lamps," and an extra "Students' Premium," value 3*l.*, to Mr. H. M. Dowsett, student, for his paper on "Electricity Meters"; the Salomons Scholarship for 1899-1900, value 50*l.*, was awarded to Mr. H. J. Thomson, a student of the Central Technical College.

THE hydrographical surveys made in H.M. surveying vessels during the year 1898, and referred to in the recent report by the Hydrographer of the Admiralty, led to a number of important results. Resurveys of parts of the Thames and Medway show that remarkable changes have taken place. An examination of the Shingles patch in the Duke of Edinburgh Channel has shown that this patch now has 15 feet of water on it, and its steady growth since 1882 has reduced the width of the Duke of Edinburgh Channel, at present the principal passage into the Thames for heavy vessels, from $1\frac{1}{2}$ miles to about $\frac{1}{2}$ a mile. The total obliteration of the passage, which seems by no means impossible, would entail a long circuit at the time of low water to large vessels to or from the Thames and Medway, but the operations of nature in this estuary are far too great to be controlled by works. A resurvey was made of the Middle Swin. This passage way, the main route for the enormous trade between London and the north, has of late years much contracted and shoaled, and gives considerable anxiety to the Trinity House, as, if necessary to alter the route, many changes in lights and buoys would be necessary to make another passage safe. There is now very little more than 19 feet on the bar at low water.

A SERIES of observations with a deep-sea current meter, carried out in the large Strait of Bab-el-Mandeb by the officers of H.M. surveying vessel *Stork*, are referred to by the Hydrographer in his report. The observations, which are valuable as bearing on the system of circulation in the oceans, have been published in a report on the under-currents of the Straits of Bab-el-Mandeb; but the broad result may be briefly stated. There was a permanent current on the surface setting *into* the Red Sea of about $1\frac{1}{2}$ knots an hour. There was at 105 fathoms depth a permanent current of about the same velocity setting *outwards*. The tidal stream was about $1\frac{1}{4}$ knots at its maximum, and flowed for about twelve hours each way, as might

be expected from the fact that in this locality there is practically only one tide in the day. This tidal stream prevails to the bottom with variations of strength. Somewhere about 75 fathoms below the surface is the dividing line between the two permanent currents, but there were not sufficient observations to determine the exact depth with any precision.

IN the current number of the *Psychological Review*, Prof. Wesley Mills points out that in investigating the psychology of animals, care must be taken to observe them under conditions as nearly approaching their normal surroundings as possible. He maintains that to place a cat in a box, as has been done, and then to expect it to act naturally, is about as reasonable as to enclose a living man in a coffin, lower him, against his will, into the earth, and attempt to deduce normal psychology from his conduct. Besides, the highest animals should be compared with the lowest human beings before maintaining that there is an essential difference between the respective mental lives of animals and the human race.

A SERIES of instructive experiments on young chicks have been made by Dr. Edward Thorndike. About sixty chicks of all ages were studied, and some remarkable instances of instinctive muscular coordination and emotional reaction were observed. A four days' chick will jump down a distance eight times his own height without hurting himself. Thrown into a pond, he will make straight for the shore, while an adult hen would float about aimlessly. For the first four or five days there is no fear of strange objects or sounds, such as the sight of a man or a hawk's cry. Instinct does not always lead to the same reaction. A loud sound may make one chick run, another crouch, another give the danger call, and another do nothing whatever.

AT Montgomery, Alabama, the daily forecasts of the U.S. Weather Bureau are shown on all street letter-boxes. The postman who collects the letters also fixes the forecast cards in position, so that the morning predictions of weather become known throughout the city by about 1 p.m. of the date of issue.

THE *Mitteilungen aus den deutschen Schutzgebieten* contains a valuable contribution to our knowledge of the Harmattan winds in the form of three short papers by competent observers in Togoland, and a discussion of the material by Dr. von Danckelmann. The investigation leads to the conclusion that the Harmattan, strictly so called, is a strengthening of the general north to south movement of the atmosphere prevalent in the western Sudan between October and April, caused by special modifications in the distribution of pressure which are not yet fully explained. The excessive dryness of the air, and its dustiness, are due to the origin of the current in the regions north of the bend of the Niger; and it is shown that the wind may penetrate into coast districts normally exposed to the influence of the moist sea breeze. The characteristic low morning temperatures are probably due to excessive radiation, but the point requires further elucidation.

WE have received the seventh annual report of the Sonnblick Society, for the year 1898, containing the meteorological observations on the summit of the Sonnblick mountain, lat. 47° 3′ N., long. 12° 57′ E., altitude 10,191 feet, and also at two intermediate stations, respectively nearly 4000 and 3000 feet above the sea. The observations have been carried on with great care and regularity, and the observatory on the summit is now under the entire management of the Austrian Meteorological Society. The difficulty of carrying on the work of this important station may be gauged from the following results for the year. The mean annual temperature was 22°·3, the absolute maximum 46°·4, and the minimum minus 13°·7. Fog occurred on 250 days, and rain (or snow) on 200 days. The report also contains useful detailed information respecting the mineral products of the neighbourhood, and particulars relating to the high observatories in the Alps.

THE Central Physical Observatory of St. Petersburg has recently published its *Annals* for the year 1897, consisting of two large quarto volumes. The first part contains the meteorological and magnetic observations made at the stations of the First Order, and the extraordinary observations at stations of the Second and Third Orders; for several stations, observations are published for every hour. The second part contains the meteorological observations of the Second Order stations, arranged according to the international scheme, and gives the observations made three times a day, and results for eighty-two stations, and a *résumé* of the monthly and annual means for 661 stations. Each set of observations is preceded by a detailed introduction, giving particulars of the methods employed and of the instruments used. In accordance with the decision of the Meteorological Conference at Paris in 1896, a useful list is added of all the periodical publications appearing in Russia which contain meteorological observations. The Director of the Meteorological Service is General M. Rykatcheff, Member of the Imperial Academy of Sciences of St. Petersburg.

DR. KEILHACK contributes a short paper on the hydrography of north-western Germany to the *Verhandlungen* of the Berlin Geographical Society. The relation of the later glacial deposits to the existing valleys and lakes is discussed, and a map shows the supposed successive positions of the inland ice, and the courses of the longitudinal valleys associated with each phase of its movement.

WE have received No. 3 of the "Current Papers" published by Mr. H. C. Russell in the *Proceedings* of the Royal Society of New South Wales, along with which is a chart showing the tracks of floats between September 1896 and September 1898. The additional information confirms the result stated in the second paper, that the rate of drift increases with latitude south of 30° S. One float gave an average rate of 12·4 miles per day in latitude 47°·16 S.

CHARLES WACHSMUTH (of Burlington, Iowa), who died in 1896, had for forty years zealously studied the fossil Crinoidea of the older rocks of North America, being assisted during the latter half of the period by Mr. Frank Springer. The labours of the two on "The North American *Crinoidea camerata*" have been published in an important monograph containing 838 pp. and 83 plates: and this work has now been subjected to an elaborate criticism by Mr. F. A. Bather, of the British Museum (Natural History), who has reprinted his series of articles, which were published in the *Geological Magazine* (1898–99). These critical essays form an important contribution to the study of the Crinoidea, and they are appropriately accompanied by a portrait and brief biography of Wachsmuth.

MR. ARNOLD HAGUE, in his presidential address to the Geological Society of Washington (February 1899), took as his subject the "Early Tertiary Volcanoes of the Absaroka Range." This range extends along the east side of the Yellowstone Park, in the State of Wyoming, and several of the higher peaks and the long western spurs slope gradually towards the Park, and lie within its borders. The Absarokas present a high plateau, ranging from 10,000 to over 12,000 feet above sea-level, and composed of agglomerates, tuffs, and lava flows, based upon Archæan and Palæozoic rocks, and including masses of intrusive igneous rock. The volcanic materials constitute the bulk of the mountains, and they were ejected from numerous vents and fissures at several successive epochs, mainly in the following order: early acid breccia, early basic breccia, early basalt sheets,

late acid breccia, late basic breccia, and late basalt sheets. Evidence of the long duration of the period of volcanic activity is furnished by the remains of plants found at different horizons; over 150 species having been identified, many of them new to science. In one instance, a grand old tree, *Sequoia magnifica*, was found firmly imbedded in the early basic breccia.

IN NATURE for March 9 we gave a short account of the late Prof. Cope's researches on the Vertebrate remains from the Port Kennedy bone deposit in Pennsylvania. We have since received the detailed account of the excavations carried on in 1894-96 by Mr. Henry C. Mercer (*Journ. Acad. Nat. Sc.*, Philadelphia, vol. xi. part 2, April 1899). The results lead to the conclusion that the original configuration of the fissure in which the remains were obtained was that of a deep, well-like chasm opening vertically downward from the sloping surface of a hill, and that the animals stampeded by a flood had rushed to their destruction into the abyss. We have previously mentioned the principal fossil remains obtained. Of these, no less than 377 individuals and 66 species were recognised, of which latter 40 are extinct. No traces of man were discovered, and the general evidence favours the view that the fauna is of earlier date than that which witnessed the presence of man on the American continent.

A RECORD of the work accomplished in the chemical laboratory of the Austrian Geological Survey during the year 1898 is summarised in the Director's Annual Report (*Verhandlungen der k. k. geol. Reichsanstalt*, No. 1, 1899). In addition to the petrographical examination of many rock-specimens, the official work comprised the analysis of no less than 203 samples, such as coals, rocks, ores, and waters. Additional researches, carried out for scientific purposes, are also recorded. Many samples of the materials employed in the construction of the new Danube embankments were examined and reported upon by Dr. v. John, who also concluded the analyses of various Bohemian mineral waters. The results of this last work are published in the September number of the *Jahrbuch*, 1898. Of special economic value are Herr Aug. Rosiwal's experiments for ascertaining methods which shall furnish definite standards whereby all the factors of stability determining the technical utility of building stones may be accurately measured. Some interesting results attained in this connection have already appeared in the *Verhandlungen*, Nos. 5 and 6, 1898.

WE have recently received from the publishers parts 38-40 of Prof. Enrico Morselli's "Antropologia Generale," now in course of publication at Turin. As these fasciculi deal with the intricate problem of man's evolution from the lower animals, they are of more than ordinary interest. The author has done wisely in reproducing a large number of the phylogenetic trees published by modern zoologists, thus giving his readers an opportunity of seeing in what respects they agree or differ from one another. Manifestly, however, his sympathies are with Haeckel's tree of mammals, in which, as is well known, the marsupials form an early offshoot from the main stem. As regards the anthropoids themselves, the author adopts Schlosser's tree, in which a primitive gibbon (*Prothylobates*) is taken as a starting point, from which the gibbons rise as one branch, while *Dryopithecus* forms the main stem. This latter is continued directly upwards to give rise to the orang and chimpanzee, while on one side branches the gorilla, and on the other *Pithecanthropus* and *Homo*. The weak point of this is the wide separation of the chimpanzee and the gorilla. Apart from this, the gibbon-like character in the skull of *Pithecanthropus* (which can scarcely be regarded as generically distinct from *Homa*, unless mental characteristics be taken into account) affords considerable support to the general plan of the phylogeny.

TWO reprints from the *Botanical Gazette* have reached us, by Prof. C. J. Chamberlain and Prof. J. M. Coulter, both referring to the phenomena of fertilisation and embryology in the Coniferæ.

THAT patient observer, Mr. Thomas Meehan, continues, in the *Proceedings* of the Academy of Natural Sciences of Philadelphia, his contributions to the life-history of plants, mostly relating to the phenomena of fertilisation.

THE most recently published part of Engler's *Botanische Jahrbücher*, vol. xxvi. Heft 5, is chiefly occupied with the conclusion of Kränzlin's Orchidaceæ of Guatemala and adjacent countries, and a further instalment of the editor's monograph of the Araceæ. There are also revisions of the genera *Philodendron*, *Dieffenbachia*, and *Tropaeolum*.

FOR the past ten years experiments have been carried on, on an extended scale, to test the suitability of the soil and climate of Indiana for the production of beet-sugar. The results of these experiments are now published in *Bulletin* No. 68 of the Purdue University Experiment Station (Lafayette, Ind.). They show that, wherever the needful precautions have been observed, beets of satisfactory character have been produced in every section of the State, and that it is probable that Indiana can produce enough beets of satisfactory quality to furnish the raw material for a large number of factories.

THE third part of Drs. D. S. Jordan and B. W. Evermann's "The Fishes of North and Middle America," being a descriptive catalogue of the species of fish-like vertebrates found in the waters of North America, north of the Isthmus of Panama, has been issued by the Smithsonian Institution as *Bulletin* No. 47 of the U.S. National Museum.

IT is a little surprising that Wiedemann and Ebert's "Physikalisches Practikum," the fourth edition of which has just been published by Friedrich Vieweg and Son, Brunswick, has not been translated into English. The volume contains a well-arranged and complete course of laboratory work suitable for students who are already familiar with elementary physical operations. Physical-chemical experiments receive particular attention.

MR. C. BAKER has issued a new catalogue of microscopes and accessory apparatus. Many instruments for histological and bacteriological work are included in the catalogue, and outfits suitable for various technical purposes. It is evident from the catalogue that, apart from the medical practitioner, naturalist and amateur, the microscope is being more and more used in trade and professional work.

THIRTEEN important memoirs are published in the *Atti* of the Naples Academy of Physical and Mathematical Sciences (1899, ser. ii. vol. ix). Among the subjects dealt with are: remains of great Pleistocene lakes and rivers in southern Italy, with special reference to the geological conditions which produced such plains as the great Vallone di Diano (full descriptions, with maps, are given of the Agri, Mercure, and Noce); chemical analyses of the waters of the hot springs of Iscia; contribution to the biology of ferns; flora of the basin of the Liri; and fossil fishes of the Eocene chalk of Gassino, Piedmont. The remainder of the memoirs deal with mathematical and geometrical subjects.

WITHOUT disparaging the Smithsonian Institution in the slightest degree, it may be said that the most valuable part of the Annual Report is the appendix, which comprises a selection of interesting memoirs upon scientific subjects. The report for 1897, just distributed, contains no less than thirty-eight memoirs of this kind, dealing with the position and progress of various

branches of science. The memoirs are "not for the specialist, but interesting and popular expositions of what the specialist knows to be sound and opportune." A number of the memoirs are reprints of addresses and articles which have appeared in NATURE, some are original articles, and others are translations or reprints from contributions to various scientific publications. Almost every phase of scientific activity seems to be included among the papers, and many subjects are illustrated by fine half-tone pictures. The Smithsonian Institution does good service to science by the publication of these sound and instructive surveys of the state of natural knowledge.

THE additions to the Zoological Society's Gardens during the past week include a Smooth-headed Capuchin (*Cebus monachus*) from South-east Brazil, presented by Mr. Herbert Gibson; a Palm Squirrel (*Sciurus palmarum*) from India, presented by Miss Aggie O'Connor; a Kinkajou (*Cercoleptes caudivolvulus*, ♀) from South America, presented by Mr. J. J. Quelch; a Mexican Guan (*Ortalis vetula*) from Cartagena, Colombia, presented by Captain W. H. Milner; a Martinique Gallinule (*Ionornis martinicus*), captured at sea, presented by Mr. H. O. Milner; a Leith's Tortoise (*Testudo leithi*) from Egypt, presented by Mr. S. S. Flower; a Black-tailed Wallaby (*Macropus ualabatus*, ♀) from New South Wales, three Rabbit-eared Bandicoots (*Peragale lagotis*, 3 ♂), two Spotted Bower Birds (*Chlamydodera maculata*) from Australia, two Westermann's Cassowaries (*Casuarius westermanni*) from New Guinea, a White-throated Monitor (*Varanus albigularis*) from South Africa, two Starred Tortoises (*Testudo elegans*) from India, four Elephantine Tortoises (*Testudo elephantina*) from the Aldabra Islands, deposited.

## OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL OCCURRENCES IN JUNE:—

June 1. 14h. 53m. to 15h. 40m. Occultation of the star 19 Piscium (mag. 5·2) by the moon.

7. 16h. 43m. to 17h. 53m. Partial eclipse of the sun visible at Greenwich. The greatest phase occurs at 17h. 17m., at which time 0·188 (nearly one-fifth) of the sun's disc will be obscured. At places N.W. of Greenwich the eclipse will be of somewhat greater magnitude.

11. 2h. Saturn in opposition to the sun.

15. Illuminated portion of the disc of Venus 0·904, of Mars 0·913.

20. 11h. 30m. Minimum of the variable star Algol (β Persei).

22. 7h. Saturn in conjunction with the moon.

23. 8h. 19m. Minimum of the variable star Algol (β Persei).

23. 10h. 34m. to 11h. 41m. Occultation of B.A.C. 6343 (mag. 5·8) by the moon.

24. 13h. 17m. to 14h. 12m. Occultation of *f* Sagittarii (mag. 5·1) by the moon.

25. 10h. 45m. to 11h. 48m. Occultation of B.A.C. 7145 (mag. 6·0) by the moon.

27. 12h. 59m. to 14h. 2m. Occultation of κ Aquarii (mag. 5·5) by the moon.

28. 11h. 22m. to 12h. 10m. Occultation of κ Piscium (mag. 5) by the moon.

COMET 1899 *a* (SWIFT).—

*Ephemeris for 12h. Berlin Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ | Br. |
|---|---|---|---|
| June 1 | 17 58 35 | + 56 13·1 | |
| 2 | 17 36 8 | 55 13·8 | 1·34 |
| 3 | 17 15 28 | 54 1·7 | |
| 4 | 16 56 46 | 52 39·2 | 1·18 |
| 5 | 16 39 54 | 51 9·5 | |
| 6 | 16 24 46 | 49 34·6 | 1·03 |
| 7 | 16 11 13 | 47 57·1 | |
| 8 | 15 59 12 | + 46 18·1 | 0·88 |

The comet is now passing with a greatly accelerated motion in a south-westerly direction. During the week it will traverse the constellations Draco and Herculis; on the 1st it passes close to ξ Draconis, while on the 8th it will be a little more than 1° north-west of φ Herculis. In *Ast. Nach.*, No. 3567, Prof. A. A. Nijland, of Utrecht, says that, viewed with a finder of 74 mm. aperture on May 5, the comet appeared about 5·5 mag., having a tail about 1°·5 in length.

TEMPEL'S COMET (1873 II.).—

*Ephemeris for 12h. Paris Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ ″ | Br. |
|---|---|---|---|
| June 1 | 19 34 17·4 | − 3 52 50 | 1·121 |
| 3 | 37 19·0 | 3 58 10 | |
| 5 | 40 18·6 | 4 5 17 | 1·271 |
| 7 | 43 16·1 | 4 14 21 | |
| 9 | 46 11·7 | 4 25 27 | 1·439 |
| 11 | 49 5·4 | 4 38 45 | |
| 13 | 51 57·2 | 4 54 22 | 1·625 |
| 15 | 19 54 47·2 | − 5 12 25 | |

As the comet approaches perihelion (June 18) it is rapidly becoming brighter, and should now be visible with small instruments. It reached its highest northerly declination on May 26, and is now travelling to the south-east through Aquila into the head of Capricornus.

NEW VARIABLE OF ALGOL TYPE.—M. Ceraski, of the Moscow Observatory, writes in *Astr. Nach.* (Bd. 149, No. 3567), announcing the discovery of a new variable of the Algol type in the constellation Cygnus. The star was detected by the varying intensity of its image on photographs taken during May and July 1898. Its position is

B.D. + 45°·3062. 1855. R.A. = 20h. 2m. 24·5s.
Decl. = + 45° 52·9.

Its magnitude is usually about 8·6, but on May 8 this year it was observed to be at minimum about 13·4h., Moscow mean time, its light then being nearly two magnitudes fainter than the normal.

VARIABLE RADIAL VELOCITY OF ζ GEMINORUM.—Prof. W. W. Campbell has called attention to this star in a paper communicated to the *Astrophysical Journal* (vol. ix. p. 86, 1899), where he gives the results of measures on three photographs. In *Astr. Nach.* (Bd. 149, No. 3565), M. A. Belopolsky gives the results of an extensive series of measures he has been able to obtain with the 30-inch refractor and two-prism spectrograph of the Pulkowa Observatory. The individual observations are given, and also a summation in the form of a table showing the radial velocities at stated intervals from minimum. This latter is as follows:—

| Interval from minimum | Velocity | Interval from minimum | Velocity |
|---|---|---|---|
| d. h. | | d. h. | |
| 0 2 | + 4·76 g.M. | 5 1 | − 2·70 g.M. |
| 0 12 | + 2·86 | 6 19 | + 1·96 |
| 1 12 | + 0·71 | 8 1 | + 3·00 |
| 2 1 | + 0·68 | 8 5 | + 3·02 |
| 3 1 | + 0·04 | 9 6 | + 5·06 |
| 3 12 | + 0·50 | 9 15 | + 4·41 |
| 4 1 | − 0·40 | 10 2 | + 4·11 |
| 4 13 | + 0·34 | | |

Prof. Campbell's maximum and minimum values were 20 kil. and 6 kil. respectively.

## THE RESULTS OF THE "VALDIVIA" EXPEDITION.

DR. SUPAN gives the following summary (based on the official report in the *Reichs-Anzeiger* of March 25) of the chief results of the German expedition in the *Valdivia* to Antarctic waters, in the April number of *Petermann's Mitteilungen*.

(1) Rediscovery and determination of position of Bouvet Island, first discovered by Bouvet in 1739, and sighted since then only by Lindsay (1808) and Norris (1825). The island, which lies in lat. 54° 26′ S., long. 3° 24′ E., and is 9½ kilo-

metres from E. to W. and 8 kilometres from N. to S., is a volcanic mountain, the edge of the crater rising to a height of 935 metres on the northern side. It is entirely covered with ice, which comes down to sea-level, and presents a steep wall to the sea: it would seem from this that in this region a tongue of polar cold projects northwards, a conclusion supported by the serial temperature observations. No trace of vegetation could be recognised with the telescope, and animal life appeared to be exceedingly scanty. No definite information was obtained as to the existence of Thompson Island.

(2) Enderby Land was not visited, as the course was again turned northward at lat. 64° S., but the samples of the sea-bottom yielded evidence that the land is not volcanic. Along the edge of the pack-ice the bottom was covered with diatom ooze, mixed with a larger proportion of clay the nearer Enderby Land was approached. In lat. 63° 17′ S., long. 57° 51′ E., material from ground-moraines, carried to sea by icebergs, was obtained; this consisted of gneiss, granite, schists, and one large piece of red sandstone.

(3) *Climate.*—The zone of fresh westerly winds and low barometer extends south of Africa only to lat. 55° S., and of Kerguelen only to 56½° S.; south of this a belt of calms and light variable winds extends to 60° S., and beyond 60° S. the prevailing winds are easterly. In other parts of the Southern Ocean, the westerly winds extend further south, to 60° and 64° S. latitude. Hence it may be supposed that the position of the Antarctic anticyclone is towards the western part of the Indian Ocean, and not directly over the pole.

In November 1898 the limit of drift ice was found in long. 7° E., to be in lat. 56¾° S. On the voyage from the most southerly point in the neighbourhood of Enderby Land, no icebergs were met with north of 61° 22′ S.

(4) *Oceanography.*—Amongst the most important achievements of the *Valdivia* expedition is the making of a large number of new soundings, with the discovery of an extensive deep-water area. It has hitherto been assumed that the sea-bottom rose rapidly towards the south from the Eastern Atlantic and the western part of the Indian Ocean, but it now seems likely that deep water extends from both these basins into Antarctic latitudes. Kerguelen, and the Crozet and Prince Edward Islands were regarded as projections on the margin of a supposed Antarctic plateau, and this idea had obtained so strong a hold that both V. v. Haardt (1895) and Fricker (1898) simply ignored the soundings of the *Challenger* in their maps, although these had shown depths of over 3000 metres in the Indian Ocean between long. 80° and 95° E. and lat. 60° and 66° S. In the regions sounded by the *Valdivia*, between 7° and 53° E. long., the depth has been found to exceed 5000 metres.

South of the fifty-sixth parallel, the bottom temperature was everywhere below 0° C., but nowhere below −0°·5 C. The serial temperatures in 63° S. lat., 54° E. long., in the month of December, gave the following distribution: (*a*) a surface layer, 120 metres thick, with temperatures between 0° C. and −1°·7 C.; (*b*) an intermediate layer, about 2200 metres thick, with temperatures above 0° C., and rising to 1°·7 C.; (*c*) a bottom layer of equal or greater thickness with temperatures below 0° C., but never colder than −0°·5. Temperature fell from the surface down to 80 metres, then rose to 1200 metres, and then again fell slowly to the bottom. The same arrangement was found further to the west, but the temperatures were somewhat lower, and again to the east, in the track of the *Challenger*; but in the latter case the cold surface layer is thicker, and the warm layer usually reaches to the bottom (3000 to 3300 metres), the cold under-layer being only met with in a sounding of over 3600 metres. The lowest temperature observed by the *Challenger* was −1°·7, the highest only 1°·4. The sea in the region of Enderby Land would thus seem to be favoured by relatively high temperatures, and it remains to bring this into direct relation to the warm Kerguelen stream: this must be done by more observations to the south of Kerguelen.

(5) *Marine Biogeography.*—The quantity of plankton increases down to about 2000 metres, diminishing rapidly at greater depths, although no level is destitute of animal life. The quantity of vegetable plankton, on the other hand, reaches its lowest within 300 or 400 metres of the surface. The characteristic of the Antarctic plankton is the abundance of diatoms, and the occurrence of special forms: the appearance of the Antarctic type begins as far north as 40° S., but in 50° S. the presence of forms belonging to warmer seas is still noticeable.

## THE WEARING AWAY OF SAND BEACHES.

THE rate of erosion of cliffs and land bordering on the sea, caused by the action of the waves, has been the subject of frequent investigation, and numerous records exist as to the rate at which the land is being encroached on by the sea. On low flat coasts the means of ascertaining the result of the contest between the sea and the land is more difficult to ascertain. The ordinary means of measurement is by a comparison of old charts, which are seldom trustworthy for this purpose. These charts being for navigable purposes, the depth of the water and the position of objects on shore forming sea marks were the subjects for which accuracy alone was required. The same remarks apply to old plans of estates and manors which were intended to delineate the property of the owners, the sea shore below high water not being a matter requiring trustworthy accuracy.

The results obtained by the Department of the Waterstaat in Holland, from periodical measurements of the coast adjacent to the North Sea, are therefore of great interest as showing the effect of the sea on flat beaches in low countries.

Between the years 1843–46, the Department caused to be placed all along the Dutch coast, extending from the Helder to the Hook of Holland, a distance of 75 miles, at the foot of the sand hills, oak posts at intervals of one kilometre (·62 mile) to form a permanent base line; and from these, at regular intervals, measurements have been periodically taken to the foot of the dunes on the land side, and to the low water line on the sea side.

The results are recorded in the *Proceedings* of the Dutch Institution of Civil Engineers.[1]

They are also set out in considerable detail, and tables given for the different periods, in the report of a Commission appointed to investigate the shell fishery of the coast, issued in 1896.[2]

The coast between the two parts named forms the arc of a very large circle, the depth of the embayment in the centre being 5½ miles. The main direction for the southern part faces about N.W., and of the northern part W.N.W. The winds which have most effect on the coast are those from the S.W., changing round to N.W.

The set of the flood tide is from south to north, the range decreasing from 5 feet at the Hook of Holland to 4¼ feet at the Texel. The coast line is bordered seaward by a sand beach extending from 300 to 350 feet to low water, lying at a slope of about 1 in 70; and on the land side by sand dunes, which vary from 1 to 3 miles in width and from 40 to 50 feet in height. These decrease in size towards the Texel.

With the exception of the detrital matter brought down in suspension by the river Maas, there is no source for a supply of material to feed the beach. The cliffs which border the French coast, from which the shingle and sand on the beach there is derived, terminate at Sangatte. The drift of the shingle and sand derived from the erosion of these cliffs extends only for a limited distance, and dies out a little beyond Calais and Dunkirk.

As regards the Belgian coast, the beach along which consists entirely of sand, from comparisons made by the Government engineers a few years ago of the various charts and plans dating from the beginning of the present century, and from a comparison of surveys of the coast made in 1833 and 1870, the conclusion was arrived at that no material alteration in the beach of the Belgian coast has taken place, so far as any means of comparison existed; and this was confirmed by measurements, taken in 1833 and 1870, of the height of the beach at the groynes at Ostend, Heyst and Wendyke, which showed that there had been no material alteration in the form of the beach.

The Dutch coast, between the periods to which the present investigations extend, has been subjected to two disturbing elements, in addition to one abnormally heavy gale in December 1894. The opening out of the new water way to Rotterdam through the Hook of Holland, and the construction of the harbour at Ymuiden for the entrance to the Amsterdam Canal, with the long piers extending across the beach, led to a considerable transposition of material at those parts of the shore; but the effect was local, and extended only over a short distance.

As a general result, the measurements show that during the last half-century, on the Dutch coast, the sea has been

[1] "Tidschrift Van het Koningklijk. Instituut Van Ingenieurs" (1883).
[2] "Uitkomst Van het Onderzoek of de Schelpvisscherij Langs de Noordzeekust Nadeelig Kan Zijn Voor Het Weerstandsvermogen Van Het Strand en het Behoud Der Duinen als Zeewering" (1896).

encroaching on the coast. The low water line has crept landward, and the beach has become more steep. There has also been a wasting away of the foot of the sand dunes.

For the first part of the period over which the observations extend (1843–56), there appears to have been a retreat of the low water line from the shore, and consequent increase in width of the beach, in the northern portion of the coast for the first forty-four miles, and this continued up to 1866 to a less extent. After this, the low water line began to advance landwards until 1877, when the northern beach began again to grow wider, but the decrease continued along the southern half. On an average there has been a loss of beach along the whole coast between 1846 and 1894, the total average loss for the forty-six years being 155 feet for North Holland and 108 feet for South Holland. The greatest change has taken place between the Helder and Petten, a distance of 12 miles, the low water line having advanced landward an average of 160 feet. Near Callangstoog, where the effect of the great gale of 1894 was most felt, the low water line is from 200 to 270 feet more inland than in 1846, and the foot of the dunes has been driven back more than 300 feet.

Near Zandvoort there has been a gain of 100 to 130 feet. Near Scheveningen the low water line has approached nearer the shore, for a length of about four miles for about 200 feet, and the foot of the dunes has been scoured away to an average of 100 feet, and in one place as much as 400 feet. The dunes have also wasted, although in a less degree. From the Helder to Egmont, a distance of 25 miles, there has been an average loss of about 150 feet. From there to Ymuiden the foot of the dunes has remained about stationary; and from Ymuiden to the Hook of Holland, excluding the part at Scheveningen, there has been an average gain of about 65 feet.

Ymuiden Harbour is situated nearly in the centre of the embayment, and the piers project about a mile out from the shore. The works were commenced in 1865, and finished in 1876. Since the commencement of the piers, sand has accumulated both on the north and south sides of the harbour, and in 1894 the accumulation had extended along the north pier seaward for a distance of about 1500 feet, and along the beach for 1½ miles, this being the measure of the two sides of the triangle forming the pocket where the material had collected.

On the south side of the harbour the seaward measurement of the accumulation was at the same period 360 feet, and along the beach about 1¼ miles.

The material thus accumulated appears to be due to a transposition of material, as previous to the piers the beach was increasing at this part of the coast, and has since considerably diminished.

The accumulation at the piers, forming the entrance to the Maas, which extend seaward about a mile, has not been so great. On the north side the sand has extended seaward, since the construction of the piers in 1863–72, 820 feet, the width of the extension along the beach being 2 miles. On the south side the accumulation extends outwards 700 feet. Here also there is a corresponding diminution of the beach for some distance to the north of the piers.

In December 1894 there occurred a very heavy gale, accompanied by the highest tide on the Dutch coast recorded during the present century, and an immense amount of damage was done to the fishing fleet. Out of 200 boats moored at the foot of the sand hills near Scheveningen, not one escaped without injury, and many were entirely destroyed. The damage done to the sand dunes, on which this part of the country depends for its protection from the sea, was very extensive, and throughout nearly the whole length the foot was washed away, leaving the mounds with steep sides. The stone pitching on the Helder Sea Dyke was damaged over a surface of about 5000 square yards. In North Holland, the tide broke through the sand hills in several places, and near Callanstoog the hills were breached for a distance of 2 miles, the tide inundating the low land behind.

W. H. Wheeler.

## *RESULTS OF THE SCIENTIFIC EXPEDITION TO SOKOTRA.*

During the past winter a biological and geographical investigation of the Island of Sokotra (lying in about 12° north latitude and 54° east longitude), some 600 miles south-east of Aden, was undertaken, on behalf of the British Museum, by Mr. W. R. Ogilvie-Grant, and, on behalf of the Liverpool Corporation, by the Director of Museums (Dr. H. O. Forbes). Mr. W. Cutmore, of the Liverpool Museum, accompanied the party as taxidermist. From the *Bulletin* of the Liverpool Museums we learn that the expedition landed at Aden on November 18, 1898. Political difficulties between the Government of India and the Sultan of Sokotra unfortunately caused some delay in starting, but through the kindness of the Political Resident, Brigadier-General Creagh, V.C., these days were employed in visiting Sheik Othman and Lahej in South Arabia, where collections of considerable interest were made. On December 1, the difficulties referred to having been surmounted, the party was enabled to leave for Sokotra on board the Royal Indian Marine steamer *Elphinstone*, which had most generously been placed at its disposal by the Indian Government. Permission was also kindly given to detain the vessel for some days at Abd-el-Kuri, a previously unexplored island lying between Sokotra and Cape Guardafui, the eastern horn of Africa. There four days were spent in making as complete a collection of the fauna, flora and geology of the island as the time permitted. On December 7, the expedition was landed on Sokotra, near Hadibu, the capital, and it remained on the island till February 22, 1899. On the return voyage, a second visit was paid to Abd-el-Kuri for a couple of days, to enable more complete collections from that out-of-the-way spot to be made.

A complete account of Sokotra, with a map, a list of the collections, and full descriptions of the new species obtained by the expedition, illustrated by plates and blocks, will be published as a special volume, which is now in active preparation. Meanwhile, short diagnoses of some of the more conspicuous zoological novelties are given in the May number of the *Bulletin* of the Liverpool Museums.

Dr. Forbes reports to the Museums Sub-Committee that the share which Liverpool receives of the collections is as follows:—Of mammals, there are examples of one or two species of rat, of one species of civet cat, of one species of bat, and of the wild ass. Of birds, there are some 300 specimens, 250 in skin and 50 in spirit, out of which seven species have been diagnosed as new to science; a large series of reptiles has been acquired, which contains one genus and eight species new to herpetology. Numerous scorpions, millipedes and spiders, their exact number not yet ascertained, have been obtained, among which there turn out to be at least one new genus and seven new species; the land-shells number several thousands, of which Mr. Edgar Smith, of the British Museum, has already described eight species as new to his department of zoology. No doubt others will prove to be previously unknown. Of insects—almost the whole of which were collected by Mr. Ogilvie-Grant—there are several thousands, the majority of which have not yet been examined.

The plants, of which living specimens or ripe seeds—over 200 in number—have been brought home, are not only of the highest scientific interest, but, being at this moment unique out of Sokotra, are of great commercial value. Their cultivation is being undertaken by Prof. Bayley Balfour in the Royal Botanical Gardens, in Edinburgh. The plants, when in a condition to exhibit, will attract the keenest interest of all horticulturists by the beauty of many of them and by the bizarre form of others.

The report states that the true Sokoterians are only poorly civilised Mohămedans, living in caves or rude cyclopean huts, and possess but few utensils, implements, or ornaments, and no weapons. The ethnographical collection is consequently very small. Specimens of their pottery, of their primitive quern-like mills, of their basket work, and of their weaving apparatus were, however, obtained, and also two large blocks of stone, inscribed with an ancient script, which may perhaps throw some light on the indigenes of the island in a past age, and of whose cyclopean remains photographs were obtained.

Dr. Forbes concludes his report by pointing out that among scientific circles, especially among geographers and biologists, there has everywhere been expressed the warmest appreciation of the liberality and public-spirited action of the Liverpool Museums Committee and the City Council in taking part in the exploration of Sokotra; and also a hearty recognition of the great credit which unquestionably belongs to them of having been the first non-metropolitan Committee to recognise that it was the part of a great Corporation possessing an important scientific institution like the Liverpool Museums, not only to furnish their galleries with examples of what is already known, but also to further the advancement and increase of knowledge by actively sharing in the investigation of unknown regions.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The 202nd meeting of the Junior Scientific Club was held on May 26. After private business, Mr. J. M. Wadmore (Trinity) read a paper on caoutchouc; Mr. M. Burr (New College) exhibited some live walking-stick insects; and Mr. H. E. Stapleton (St. John's) read a paper on Dulong and Petit's law.

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AN exhibition of practical work executed by candidates at the recent technological and manual training examinations of the City and Guilds of London Institute will be opened by the Duke of Devonshire, at the Imperial Institute, on Friday, June 9.

THE Edinburgh correspondent of the *Lancet* states that the court of the University of Edinburgh had recently before them a report from the committee appointed to draw up a statement and appeal for funds for University purposes, in which it was stated that the funds required for the equipment of the Public Health Laboratory and for the preparation of a library catalogue had been provided, the former by the generosity of Mr. John Usher of Norton, and the latter from the munificent bequests of the late Sir William Fraser. For the library, however, funds are still urgently required. The most pressing wants are: (1) a fire-proof room for the storage of rare books of the fifteenth and early sixteenth centuries and the MSS., which number about 7000; (2) a fund, amounting at the lowest figure to 25,000*l.*, for the purchase of scientific and literary journals and of larger works of reference; and (3) extensive structural changes and new book-cases, costing at least 5000*l.*, or a new and suitable building for the library. Another direction in which it will soon be necessary to spend money is the establishment of the Physical Laboratory. The construction and equipment of this laboratory will be a large undertaking, but it is one which will have soon to be faced if the scientific reputation of the University is to be maintained.

## SCIENTIFIC SERIALS.

*American Journal of Science*, May.—Some experiments with endothermic gases, by W. G. Mixter. The endothermic gases operated upon were acetylene, cyanogen, and nitrous and nitric oxides. A beautiful experiment described is one in which acetylene is decomposed at a dull red heat. The gas issues from a narrow tube into a wider tube, heated by a Bunsen burner. When the glass begins to glow there is a slight puff, and the stream of gas issuing from the narrow tube glows, or rather the carbon particles glow in it with the heat of dissociation of the acetylene.—A hypothesis to explain the partial non-explosive combination of explosive gases and gaseous mixtures, by W. G. Mixter. Detonating gas, a mixture of carbonic oxide and oxygen, one of cyanogen and oxygen, and other explosive mixtures of gases, do not explode below certain pressures when sparked. Explosions do not occur because of the infrequency of impacts of molecules having a velocity or internal energy adequate for chemical union. Some of the molecules combine, but the heat of their union is not sufficient to restore the energy lost by radiation, and the change is therefore not self-propagating.—Occurrence of palæotrochis in volcanic rocks in Mexico, by H. S. Williams. Origin of palæotrochis, by J. S. Diller. These two papers effectually dispose of the hypothesis of the organic origin of the siliceous formations described by Emmons as due to some primordial coral. Prof. Williams describes some specimens coming from an old eroded volcanic cone made up of altered porphyry and volcanic tuffs, situated north-east of Guanajuato in the Santa Rosa mountains. A microscopical study of thin sections reveals the fact that the nodules are spherulites, a common feature of acid igneous rocks.—Association of argillaceous rocks with quartz veins in the region of Diamantina, Brazil, by O. A. Derby. Red clay is always associated with the quartz veins of the diamond region of Minas Geraes, Brazil. The author describes a remarkable layer of that kind, one to two metres thick, which has received from the miners the name of *Guia* (Guide), because, as they state, diamonds were to be looked for below the outcrop of this layer, and not above it.—Volatilisation of the iron chlorides in analysis, and the separation of the oxides of iron and aluminium, by F. A. Gooch and F. S. Havens. The fact that ferric oxide is completely volatile in HCl gas applied at once at a temperature of 500°, and at 200° if the acid carries a little chlorine, opens the way to many analytical separations of iron, notably to the separation of intermixed iron and aluminium oxides.—Preliminary note as to the cause of root pressure, by R. G. Leavitt. The author applies the latest researches on osmotic pressure to the known facts of plant physiology.

*Bulletin of the American Mathematical Society*, May.—Prof. Holgate gives an account of the April meeting, of the Chicago Section, at Evanston, April 1. There were two sessions in the day, and twelve papers were communicated.—Prof. Bôcher gives an elementary proof that Bessel's functions of the Zeroth order have an infinite number of real roots. This was read at the Society's February meeting (*cf.* Gray and Mathews' "Treatise on Bessel Functions," p. 44.) A generalisation of Appell's factorial functions (read at the December 1898 meeting), by Dr. Wilczynski, is a slight modification of Appell's proof. The writer proposes to discuss these functions more fully later on. A paper, read at the February meeting, by Prof. J. Pierpont, entitled "On the Arithmetization of Mathematics," is an attempt to show why arithmetical methods form the only sure foundation in analysis at present known. General reasons are indicated in a paper by Klein ("über Arithmetisirung der Mathematik," *Gottinger Nachrichten*, 1895). The paper enters into considerable detail. There is much metaphysics as well as mathematics.—Prof. E. W. Brown contributes an appreciatory review of Prof. Darwin's work on the tides and kindred phenomena of the solar system, and also notices "Leçons sur la théorie des Marées," by Maurice Lévy.—The Notes give an account of a projected change in the "Annals of Mathematics," which is to be inaugurated in vol. xiii., and a full list of the subjects of lectures at a dozen German universities, besides some notes of personal matters.

*Wiedemann's Annalen der Physik und Chemie*, No. 4.—Pitches of very high notes, by F. Melde. The author reviews the various methods by which very high pitches have been determined. These include subjective methods like those by direct hearing and by difference tones, and objective ones like the various vibrographs and the author's own method of resonance. The author admits that the method of difference tones is untrustworthy, and points out certain advantages of the sensitive flame which might be utilised.—Viscosity of gases, by P. Breitenbach. Of the two methods for determining the viscosity of gases, that of transpiration through a capillary tube, and that of the oscillation of a solid, the latter indicates a greater increase of viscosity in the temperature. But in any case the increase is not quite proportional to the temperature.—Effect of electric oscillations upon moist contacts, by E. Aschkinass. Two pointed copper wires which just touch each other act as an ordinary coherer in air or alcohol, but when immersed in water, or when the points are only connected by a drop of water, the action is reversed, since electric waves have the effect of temporarily increasing instead of reducing the resistance. In another form of the experiment, a few drops of water are added to the copper filings of an ordinary coherer. This reversed action is as yet entirely unexplained.—Emission and absorption of platinum black and lamp black with increasing thickness, by F. Kurlbaum. The emission of blackened surfaces is compared with that of an "absolutely black body" in the shape of an orifice of a brass vessel blackened inside and kept at a constant temperature by circulating steam. A bolometer is exposed to radiation from this orifice and to films of black substances kept at the same temperature. It appears that platinum black has a higher absorptivity and emissity at greater thicknesses, whereas that of lamp black is greater in very thin layers. Neither of these substances absorbs heat rays of great wave-lengths. For most purposes, platinum black is to be preferred, if only on account of the facility in controlling its electrolytic deposition.—Radius of molecular action, by W. Mueller-Erzbach. Films of bees-wax or sealing-wax were protected by thin layers of gum against the dissolving action of carbon bisulphide vapour. The thickness of the layer of gum required for effectively protecting sealing-wax was 0·35 mm., whereas bees-wax was sufficiently protected by a layer only 0·14 mm. thick.

THE April issue (vol. lxv. part 4) of the *Zeitschrift für Wissenschaftliche Zoologie* contains five articles, of which, perhaps, the one by Messrs. Eimer and Fickert, on the evolutionary history of the Foraminifera, is the most generally interesting.

More than one hundred pages of the journal are devoted to this subject; and the elaborate genealogical tree given on p. 464 supplies in concise form the general results of the authors' investigations. The other articles include one on the Infusoria found in the stomachs of domestic Ruminants, by A. Günther; one on the urinogenital system of certain Chelonians, by F. von Müller: a third, by J. Meisenheimer, on the morphology of the kidneys of the Pulmonate Mollusca; and a fourth, by G. Forssell, on the Lorenzinian ampullæ in the Spiny Dogfish. After describing in detail the histology of these head-organs, the author considers that further experiments must be made before their precise function can be fully determined.

## SOCIETIES AND ACADEMIES.

### London.

**Physical Society**, May 26.—Mr. T. H. Blakesley, Vice-President, in the chair.—A paper, by Prof. S. Young and Mr. Rose-Innes, on the thermal properties of normal pentane (Part 2), was read by Mr. Rose-Innes. In the first paper on this subject, read before the Physical Society last December, it was shown that the relations existing between the volume temperature and pressure of normal pentane could be closely represented by the equation

$$p = \frac{RT}{v}\left\{1 + \frac{e}{v + k - gv^{-2}}\right\} - \frac{l}{v(v+k)}.$$

This formula was first used in connection with isopentane, and it has been shown that the values of R and $l/e$ are the same for the two isomers. The authors find that if $l$ and $e$ be taken separately equal to each other, and if the constants $k$ and $g$ be calculated from experiments on normal pentane, errors of 2 per cent. occur between the calculated and experimental results. This point has been investigated both algebraically and graphically, and the supposition that these constants are separately equal has been thought incorrect. Taking the values of R, $l/e$, and $g$ as being the same in the two pentanes, the constants $l$ and $k$ have been determined, and by this means the relations between volume temperature and pressure have been represented by the formula to within 1 per cent. The authors conclude that the difference in pressure of two isomeric substances at a given volume and temperature is of the same order as the deviation from Boyle's law, and involves the second power of the density. Mr. Rose-Innes said the formula proposed was not an absolute solution of the problem, although it was the best of a large number which had been tried. It has been applied with success to Andrews' experiments on carbonic acid, and to experiments which have been made upon ether and hexane. In the latter case, the range in volume was too small to afford a rigorous test of the value of the formula. The range in volume in isopentane was from 4000 to 3·4; in normal pentane, from 300 to 3·4; and in ether, from 350 to 3·4. The temperature varied in different experiments from 40° C. to 280° C. Objections have been raised to the formula on account of the number of constants it contains and its complexity. Mr. Rose-Innes pointed out that it was necessary to have a complex formula, as they were not dealing with a simple problem, but with the results of experiments which went so far below the critical temperature that the volume occupied was only 3·4 times as great as the space which would have been occupied by the molecules at their closest packing. The reader of the paper compared the proposed formula with formulæ of Clausius, Sutherland, and Tait containing four, four, and six constants respectively, and finally with the original equation of Van der Waals applied to experimental results by Amagat. It was shown that the agreement was much closer and the range greater. Prof. Callendar expressed his interest in the wide applicability of the authors' formula, and asked if any theoretical significance could be assigned to the various constants which appeared. Mr. Rose-Innes said the R of their formula was the R of the perfect gas equation, and that the $l$ and $e$ corresponded respectively to the $\beta$ and $\alpha$ of the ordinary Van der Waals expression. So far as he knew, the $k$ and $g$ were meaningless.—A paper on the distribution of magnetic induction in a long iron bar, by Mr. C. G. Lamb, was postponed until the next meeting.

**Chemical Society**, May 18.—Prof. Thorpe, President, in the chair.—The following papers were read:—Corydaline (Part vi.), by J. J. Dobbie and A. Lauder. Corydaldine, $C_9H_7NO(OMe)_2$, an oxidation product of corydaline, is shown to be closely related to oxyhydrastinine; the so-called corydalinic acid is an acid ammonium hemipinate.—Oxidation of furfural by hydrogen peroxide, by C. F. Cross, E. J. Bevan and T. Heiberg. Furfural is oxidised by hydrogen peroxide in presence of iron salts to a hydroxyfurfural and the corresponding hydroxypyromucic acid; the hydroxyfurfural reacts with phloroglucinol and resorcinol in a similar way to the lignocelluloses. It is shown thus that a furfuralphenol is a constituent of the lignocelluloses.—Note on the reactions between sulphuric acid and the elements, by R. H. Adie.—On the action of ethylene dibromide and of trimethylene dibromide on the sodium derivative of ethylic cyanacetate, by H. C. H. Carpenter and W. H. Perkin, jun. Improved methods for preparing tri- and tetra-methylene derivatives are given. Ethylic trimethylenecyanocarboxylate (1,1), is prepared by the action of ethylene bromide on ethylic sodiocyanoacetate, and ethylic tetramethylenecyanocarboxylate (1,1), is obtained by the action of trimethylene bromide on ethylic sodiocyanoacetate; the salts are hydrolysed by cold alcoholic potash with formation of the corresponding acids.—The maximum vapour pressure of camphor, by R. W. Allen. Experimental values for the maximum pressures of camphor vapour at 0–80° are given.

**Linnean Society**, May 4.—Mr. A. D. Michael, Vice-President, in the chair.—Mr. I. H. Burkill exhibited specimens of a daisy (*Bellis perennis*), found at Kew, in which the ray of the outer florets was so nearly absent that these consisted of scarcely more than ovary, naked style, and stigma.—Mr. F. G. Parsons read a paper on the position of *Anomalurus* as indicated by its myology. The paper contained an account of the muscles of *Anomalurus*, and a comparison of them with those of the different suborders of rodents. From previous examination of the muscles of rodents, the author arrived at the conclusion that *Anomalurus* should be placed among the Sciuromorpha, but that it had certain Myomorphine tendencies. He contrasted its muscles with those of *Pedetes caffer*, but found little reason to regard these two animals as nearly related.—Mr. George Murray, F.R.S., on behalf of Miss Ethel S. Barton, communicated a paper on *Notheia anomala*, an obscure species of parasitic Alga, and described its mode of growth and reproduction, some remarks being made by Mr. W. Carruthers, F.R.S.—A paper by Mr. George West on variation in Desmids was read. The Desmidieæ was shown to be morphologically specialised and to exhibit a marked pattern and symmetry of form, major and minor symmetries being recognisable in many species. Variations in form and symmetry were specially dealt with, and a summary given of all that is known concerning the variation in the cell-contents and in the conjugation of these plants. Observations were also made on the variability of the pyrenoids and moving corpuscles in the genus *Closterium*.

**Geological Society**, May 10.—W. Whitaker, F.R.S., President, in the chair.—The geology of the Davos district, by A. Vaughan Jennings. Alpine geology has attracted many workers since the date of Prof. Theobald's classic memoir on the district of which Davos forms part, and new principles of interpretation have been established. The author has more especially studied (*a*) the age of certain rocks formerly classed as "Bündner Schiefer," but distinct from the grey shales variously regarded as of Jurassic or Tertiary age; (*b*) the origin and date of the serpentine near the Davoser See; and (*c*) the tectonic structure of the district. The author discusses at length the physical structure of the district. The general trend of the Davos Valley is rather oblique to that of the greater rock-masses, which, however, is somewhat irregular. He shows that these (which have a general dip towards the south and east) form three great acute and rudely parallel over-folds, the westernmost being the most complicated; of this fold, the serpentine forms a part. It is more recent than the crystalline schists and the Casanna Schiefer, and is associated with the red and green schistose rocks already mentioned, in a way which he considers indicative of intrusion; but it nowhere cuts the Haupt-Dolomit. Accordingly he considers it to be later than the Verrucano, and not earlier than the middle part of the Trias. Certain crystalline breccias occur in the neighbourhood of the serpentines; these the author considers to be due to earth-movement, and he goes on to give reasons for regarding them as the equivalent of the Casanna Schiefer of other localities. There is, in his opinion, no evidence of the presence of

post-Jurassic strata such as Prof. Steinmann believes to exist.—Contributions to the geological study of County Waterford. Part 1, § i. The Lower Palæozoic bedded rocks of the coast, by F. R. Cowper Reed. This paper opens with an account of the previous publications on the geology of the district, and then goes on to describe the sections exposed along the coast at the following localities: Raheen and Newtown Head, Tramore Bay, Garrarus and Kilfarrasy, Annestown and Dunabrattin, Knockmahon, Ballydouane Bay, and Killelton Cove to Ballyvoyle. These sections expose shales and limestones with abundance of igneous rocks partly interbedded, but mainly intrusive; and the author is able to make out the following succession of rocks, tabulated in descending order: (4) Raheen Series. Mudstones, slates, felsites and tuffs, and fossiliferous shales. (3) Carrigaghalia Series. Graptolitic shales, thin flags, cherts, tuffs, and felsites. (2) Tramore Limestone Series. Divided into three stages. (1) Tramore Slates. Calcareous and argillaceous slates.

Zoological Society, May 16.—Dr. W. T. Blanford, F.R.S., Vice-President, in the chair.—The Secretary read extracts from letters received from Mr. J. S. Budgett, containing an account of the progress of his expedition to the Gambia, and announcing his proposed return in July next.—Mr. G. A. Boulenger, F.R.S., exhibited a specimen of the Bornean lizard (*Lanthanotus borneensis*), belonging to the Sarawak Museum, and remarked that it was the second example of this reptile that had reached Europe. An examination of the specimen had confirmed Mr. Boulenger's suspicion that its affinities were with the *Helodermatidae*, and that it was not, as its original describer (Steindachner) had supposed, entitled to family rank by itself.—Mr. G. E. H. Barrett-Hamilton exhibited the skins of two hares (*Lepus variabilis*), and made some remarks on the winter whitening of Mammals in connection therewith.—Mr. G. A. Boulenger, F.R.S., read an account of the fishes obtained by the Congo Free State Expedition, under Lieutenant Lemaire, in Lake Tanganyika, in 1898. Ten new species were described, of which three were made the types of new genera.—Mr. E. M. Corner read a note on the variations of the patella in the divers, grebes, and cormorants, by which the functions of the bones in these birds were explained.—A communication was read from Mr. Stanley S. Flower, containing notes on a second collection of reptiles made in the Malay Peninsula and Siam, from November 1896 to September 1898, and a list of the species recorded from those countries. The species enumerated in the paper were 221, of which one was the type of a new species, described under the name of *Typhlops floweri* by Mr. G. A. Boulenger.—A communication was read from Marquis Ivrea on the wild goats of the Ægean Islands. A series of heads and some photographs of the goats of the islands of Antimilo and Joura were exhibited, with the object of showing that the effect of a cross between *Capra aegagrus* and *C. hircus* (such as had been proved to have occurred on the former island) was not to produce an animal corresponding to *C. dorcas* (Reichenow), and that consequently the goat of Joura had not, as was generally assumed, been so produced, but was, as a matter of fact, a local variety of the wild goat, for which the name *C. aegagrus*, var. *jourensis*, was suggested. Mr. W. Cunnington read a paper on a new Brachyuran Crustacean from Lake Tanganyika, obtained by Mr. J. E. S. Moore, for which he proposed the name *Limnothelphusa maculata*. The crab, unlike its nearest allies, was wholly aquatic, and would seem to be the most primitive member of the Thelphusine group.—A paper was read by Mr. W. T. Calman on some Macrurous Crustaceans obtained by Mr. J. E. S. Moore in Lake Tanganyika. A new genus (*Limnocaridina tanganyikae*) and a new species of *Palaemon* (*P. moorei*) were described, it being pointed out that neither of them furnished any particular facts bearing on the general question of the origin of the Tanganyikan fauna.

CAMBRIDGE.

Philosophical Society, May 15.—Mr. J. Larmor, President, in the chair.—Mr. J. J. Lister exhibited specimens of *Branchipus* and *Estheria* raised from dry mud, obtained from the upper pool of Gihon near Jerusalem. The mud had been placed in water, after remaining dry for three years, and three days later the water was found to be peopled with the nauplius larvæ of these genera. Representatives of species of *Daphnia*, *Ostracoda* and *Copepoda* had subsequently appeared, probably identical with those described by Baird from the same locality (*Annals and Magazine of Natural History*, series iii. vols. iv. and viii.). It was pointed out that in *Branchipus* food travels forward towards the mouth along the groove which separates the thoracic appendages of the opposite sides; and the suggestion was offered that a similar course of the food may explain the masticatory character of the basal inner lobes of the anterior thoracic appendages of *Apus*.—Notes on the Binney collection of carboniferous plants; (2) a new type of Palæozoic plant, by A. C. Seward. The author gave a brief description of a fragment of stem from the Coal-Measures of Lancashire, which exhibits anatomical features differing from those of any known genus. The primary structure agrees in certain respects with that of *Heterangium*; but there are definite peculiarities which render advisable the institution of a new generic name. Among the more important characteristics may be mentioned the large isodiametric metaxylem tracheids, the position of the protoxylem elements and the structure and course of the leaf-traces.—On the modification and attitude of *Idolum diabolicum*, a Mantis of the kind called "floral simulators," by Mr. D. Sharp. Mantises are voracious insects with the front legs of remarkable form, suited to the capture of living insects which form the sustenance of the Mantis. Certain of these Mantises assume attitudes and make movements that cause them to resemble flowers, and they are moreover possessed of some modifications of structure and colour that are believed to strengthen the illusion caused by their attitudes. The facts as regarded *Idolum diabolicum* were stated, and from a comparison with other Mantises the conclusion was deduced that the modifications of structure are really slight, and that the attitude is the important point. In reference to the origin of the peculiarities, he concluded that, granted that the instinct of the creature caused it to assume the attitudes, the slight structural modifications might follow from simple physical causes.—On the product $J_m(x)J_n(x)$, by Mr. W. McF. Orr.

PARIS.

Academy of Sciences, May 23.—M. Van Tieghem in the chair.—On the deformation of general surfaces of the second degree, by M. Gaston Darboux.—On some new compounds of camphor with aldehydes, by M. A. Haller. In continuation of previous work on the subject, the author has studied the action of piperonal and of meta- and para-methoxybenzaldehydes on the sodium derivative of camphor, and has prepared a number of new compounds. Metamethoxybenzylidenecamphor crystallises in long needles melting at 51°–52° and is reduced by sodium amalgam to metamethoxybenzylcamphor. Paramethoxybenzylidenecamphor forms large crystals melting at 125°, and is converted by reduction into paramethoxybenzylcamphor, which crystallises in prisms melting at 71°. Piperonylidenecamphor crystallises in needles melting at 159°·5, and yields, on reduction, piperonylcamphor, which forms small white plates melting at 70°. Piperonyl piperonylate, which is formed along with piperonylidenecamphor, crystallises in needles melting at 97°.—On isothermic surfaces and the deformation of the paraboloid, by M. A. Thybaut.—On the deformation of certain surfaces related to surfaces of the second degree, by M. Tzitzeica.—On the development of a uniform branch of analytic functions, by M. Paul Painlevé.—On the calculation of divergent series by Taylor's theorem, by M. Emile Borel.—On the calculation of the maximum available force at the draw-bar of a motor, by M. A. Petot.—On the decomposition of silicates by hydrogen sulphide, by M. P. Didier. The majority of silicates, when heated in a porcelain tube at about 1400° C., are decomposed and partially converted into sulphides. In some cases, the latter are easily separated, owing to the occurrence of volatilisation or of crystallisation, or by their solubility in dilute acids; in others, the sulphides obtained are only attacked by reagents which decompose the original silicate. The reaction is always incomplete, since the silicate becomes covered with a protective layer of sulphide, and in the greater number of experiments the somewhat remarkable formation of a small quantity of sulphuric acid was noted. A portion of the silica appears to be reduced to silicon, and this is also found to occur in the action of hydrogen sulphide on silica alone.—On di-isoamylacetic acid, by M. H. Fournier. Ethylic di-isoamylmalonate, obtained by the malonic ether synthesis from isoamylic bromide, is a colourless liquid boiling at 278°–280°, and the corresponding acid crystallises in white plates melting at 147°–148°. The latter, when heated to 175°, is converted into di-isoamylacetic acid, which crystallises in white needles melting at 46°–47°, and is insoluble in water but very

soluble in organic solvents. The corresponding amide crystallises in white, silky needles melting at 115°.—Fluorine in mineral waters, by M. Charles Lepierre. It is maintained, in opposition to M. Parmentier, that minute traces of fluorides have been detected in many natural waters, and that considerable quantities —equivalent to 10 or 12 milligrammes of fluorine per litre—are present in the mineral water of Gerez (North Portugal), which is much esteemed for its efficacy in diseases of the liver.—On the genesis of the iron ores of Lorraine, by M. P. Villain. Arguments are brought forward in support of the theory that the oolitic ore of Lorraine is a littoral deposit, the mineralisation of which has been effected by the action of hot springs in the bed of an ancient sea.—On a parasitic fungus in cancerous affections, by M. J. Chevalier. The author has succeeded in isolating what appears to be a specific fungus from cancerous tumours, from the blood of patients, and from the air of hospitals. A temperature of from 28° to 35° is most favourable to its growth, but it is highly resistant, the spores not being destroyed by ten minutes' heating at 100°. The parasite exists in the form of conidia, a mycelium, or spherules, according to the stage of development and the medium employed. Its specific character is confirmed by the results of inoculation experiments, but further study will be required before the causal connection between the parasite and cancerous affections is definitely established.

## DIARY OF SOCIETIES.

*THURSDAY*, JUNE 1.

ROYAL SOCIETY, at 4.—Election of Fellows. —At 4.30 —The Parent-Rock of the Diamond in South Africa: Prof. T. G. Bonney, F.R.S.—Experimental Contributions to the Theory of Heredity. A. Telegony.—I. Introductory: Prof. J. C. Ewart, F.R.S.
ROYAL INSTITUTION, at 3.—Water Weeds: Prof. L. C. Miall, F.R.S.
LINNEAN SOCIETY, at 8.—On the High Level Plants of the Andes as illustrated by the Collections of Sir W. Martin Conway, Mr. Edward Whymper, and others: W. Botting Hemsley, F.R.S.—On some Australasian Collembola: Sir John Lubbock, Bart., F.R.S.
SOCIETY OF ARTS, at 4.30.—The Port of Calcutta: Sir Charles Cecil Stevens, K.C.S.I.
CHEMICAL SOCIETY, at 8.—The Hydrosulphides, Sulphides, and Polysulphides of Potassium and Sodium: W. Popplewell Bloxam.—On the Relative Efficiency of various Forms of Still-head for Fractional Distillation: Dr. Sydney Young, F.R.S.—The Salts of Dimethylpyrone, and the Tetravalence of Oxygen: Dr. J. N. Collie, F.R.S., and Thomas Tickle.

*FRIDAY*, JUNE 2.

GEOLOGISTS' ASSOCIATION, at 8.—The Pleistocene Deposits of the Ilford and Wanstead District: Martin A. C. Hinton.—The Pleistocene Mollusca of Ilford: A. S. Kennard and B. B. Woodward.—The Raised Beach and Rubble Drift at Aldrington, between Hove and Portslade-by-Sea, Sussex, with Notes on the Microzoa: Frederick Chapman.

*SATURDAY*, JUNE 3.

GEOLOGISTS' ASSOCIATION.—Excursion to Reigate. Directors: Miss M. C. Crosfield and Rev. Ashington Bullen.

*MONDAY*, JUNE 5.

ROYAL GEOGRAPHICAL SOCIETY, at 3.—Anniversary Meeting.
SOCIETY OF CHEMICAL INDUSTRY, at 8.—A New Method for the Analysis of Commercial Phenols: Dr. S. B. Schryver.—A Demonstration of Printing by Electricity without the aid of Rollers or Ink: Dr. S. Rideal.—Notes on Cacao Butter: Dr. J. Lewkowitsch.—The Use of Iron as the Active Element in Primary Batteries and for Electrolysing: Colonel J. Waterhouse.

*TUESDAY*, JUNE 6.

ZOOLOGICAL SOCIETY, at 8.30.—An Account of a Collection of Fishes made by Mr. R. B. N. Walker on the Gold Coast: Dr. A. Günther, F.R.S.—On a Specimen of *Cervus belgrandi*, Lart. (*C. verticornis*, Dawk.) from the Forest-Bed of East Anglia: Dr. S. F. Harmer, F.R.S.—On a Few Points in the Structure of Laborde's Shark (*Euprotomicrus labordii*, Müll. and Henle): Dr. R. O. Cunningham.

*WEDNESDAY*, JUNE 7.

GEOLOGICAL SOCIETY, at 8.—On the Geology of Northern Anglesey: C. A. Matley.—On an Intrusion of Granite into Diabase at Sorel Point (Northern Jersey): J. Parkinson.
ENTOMOLOGICAL SOCIETY, at 8.

*THURSDAY*, JUNE 8.

ROYAL SOCIETY, at 4.30.—Meeting for Discussion.—*Subject*: On Preventive Inoculation: introduced by M. Haffkine.
MATHEMATICAL SOCIETY, at 8.—On Solitary Waves, Equivoluminal and Irrotational, in an Elastic Solid: Lord Kelvin, G.C.V.O.—On Several Classes of Simple Groups: Dr. G. A. Miller.—The Transmission of Stress across a Plane of Discontinuity in an Isotropic Elastic Solid and the Potential Solutions for a Plane Boundary: Prof. J. H. Michell.—On Theta Differential Equations and Expansions: Rev. M. M. U. Wilkinson.—Finite Current Sheets: J. H. Jeans.—On a Congruence Theorem having reference to an Extensive Class of Coefficients; and on a Set of Coefficients analogous to the Eulerian Numbers: Dr. Glaisher, F.R.S.

*FRIDAY*, JUNE 9.

ROYAL ASTRONOMICAL SOCIETY at 8.
MALACOLOGICAL SOCIETY, at 8.

## BOOKS, PAMPHLET, and SERIALS RECEIVED.

BOOKS.—Handbuch der Anatomie und Vergleichenden Anatomie des Centralnervensystems der Säugetiere: Drs. E. Flatau and L. Jacobsohn, 1. (Berlin, Karger).—Annales de l'Observatoire National: d'Athènes, Tome 1 (Athènes).—The Use of Lead Compounds in Pottery: W. Burton (Simpkin).—Catalogue of the Library of the Royal Botanic Gardens, Kew (London).—The Psychology of Reasoning: Dr. A. Binet (K. Paul).—An Introduction to the Study of Materia Medica: Prof. H. G. Greenish (Churchill).—La Crime, Causes et Remèdes. C. Lombroso (Paris, Schleicher).—The Coccidæ of Ceylon: E. E. Green, 2 Parts (Dulau).—The Geography of Mammals: W. L. Sclater and Dr. P. L. Sclater (K. Paul).—Animals in Motion: E. Muybridge (Chapman).—Antiquities from the City of Benin, &c., in the British Museum: C. H. Read and O. M. Dalton (London).

PAMPHLET.—Geology of the Country around Carlisle: T. V. Holmes (London).

SERIALS.—Quarterly Journal of Microscopical Science, May (Churchill). Papers read before the Engineering Society of the School of Practical Science, Toronto, No. 12, 1898–99 (Toronto).—Agricultural Gazette of New South Wales, April (Sydney).—American Geologist, May (Ginn).—Records of the Australian Museum, Vol. 3, No. 5 (Sydney).—Proceedings of the Royal Physical Society, Session 1897–98 (Edinburgh).—Himmel und Erde, May (Berlin).—Memoirs of the Geological Survey of India, Vol 28, Part 1 (Calcutta).—Journal of Applied Microscopy, April (Rochester, N.Y.).—North American Fauna, No. 14 (Washington).—Science Gossip, June (Strand).—English Illustrated Magazine, June (Strand).—Chambers's Journal, June (Chambers).—Bulletin of the American Mathematical Society, May (New York).—Good Words, June (Isbister).—Sunday Magazine, June (Isbister).

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THURSDAY, JUNE 8, 1899.

## MAN, PAST AND PRESENT.

*Man, Past and Present.* By A. H. Keane. "Cambridge Geographical Series." Pp. xii + 548, illustrated. (Cambridge University Press, 1899.)

A TRUSTWORTHY and up-to-date work in a small compass on "Ethnology" in its wider sense, in which the human race should be considered in greater detail from a zoological (anthropological) rather than from a linguistic and cultural (ethnological) point of view, was a decided want in this country. And this want has been well supplied by the volume before us, with its precursor in the same series published three years ago under the title of "Ethnology." It is, however, in our opinion, a matter for distinct regret that the author and the editor did not at first starting definitely make up their minds as to the extent to which the subject of ethnology (again using the term in its wider sense) was to figure in the series. Had this been done, a considerable amount of useless and irritating repetition might have been avoided, while the present volume would have been much more fully illustrated.

According to the present arrangement, the second part of the "Ethnology" treats of the primary divisions of mankind, of which the author recognises four; and in each of these divisions the chief groups or sections are described in more or less detail. In the present volume, on the other hand, attention is directed to the detailed classification of the various groups and races of the four main divisions. It would have been far preferable had the descriptions of the main divisions given in the first volume been immediately followed by the detailed history of the race-groups which appears in the second, with a blending of some of the matter relating to these latter from the "Ethnology," and the omission of the rest. The numerous excellent illustrations of racial types in the first volume would then have been available for the detailed descriptions in the second, where they are now so sorely needed. To illustrate what we mean, we may refer to the notices of the Andamanese on p. 256 of the first, and p. 158 of the second volume. In both instances we are informed that these people were miscalled "Mincopies," in both that their language is unlike any other, and in both that their numerals only extend to two, but that ten can be counted by means of the fingers. Again, if the accounts of the Bushmen and Hottentots on pp. 248 and 250 of the first, and p. 121 of the second volume be compared, it will be found that while there is a certain amount of repetition; neither is complete without the other, so that a judicious blending is clearly required.

But this is not quite all the fault we have to find with the general plan adopted by the author, who, we venture to suggest, would be all the better for a little training in descriptive zoology. For instance, in neither volume do we find a definite description of the characters of the Negroid division ("*Homo aethiopicus*"), as distinct from all other divisions; although in the one under consideration we have many such division-characters given as distinctive of a minor group, to wit, the Sudani negroes. Still more pronounced is this confusion in the case of the Mongoloids ("*Homo mongolicus*"), of which the division-characters are correctly given on p. 297 of the first volume, only to be repeated as group-distinctions on pp. 169 and 170 of the second. And here it may be mentioned that, since the author insists very strongly on the specific unity of mankind, he has no justification for using the names above referred to. The proper terms should, of course, be *Homo sapiens aethiopicus* and *H. s. mongolicus*.

In his treatment of the four main divisions of mankind in the present volume, the author commences with the Negroid; and his clear account of the essential difference between the Sudani and Bantu sections of African Negroes affords an important contribution to a very difficult subject, in which a considerable amount of new matter appears. It is, however, a matter for regret that the author has seen fit to discard M. Hamy's convenient term "Negrillos" for the dwarf races of equatorial Africa, since if they are called Negritos, it is liable to lead to confusion with the Andamanese and other Oceanic Negroid races. In treating of the southern Bantu, the author draws attention to the fact that the term Kaffir is only a corruption of the name Kafir applied indiscriminately by Muhammedans to all unbelievers, as exemplified by the Siahposh Kafirs of Central Asia. He consequently suggests the substitution of "Zulu-Xosas" for Zulus and Kaffirs; but unless, which is extremely unlikely, this meets with popular acceptation, the proposed change does not seem advantageous. Mr. Keane fully supports Sir Harry Johnston's estimate of the non-progressive nature of the Negro character (even in its Bantu modification); and he accordingly agrees with Mr. Bent in regarding the Zimbabwe ruins as of Arabic origin.

In the classification of the oceanic members of the Negroid group, the author follows the generally received views. He, however, considers that the Papuans, although nearly allied to Melanesians, should not be merged in the latter, and therefore proposes the term Papuasians for the two. On p. 145 he states that

"the ethnological parting-line between the Malayan and Papuasian races, as first laid down by Wallace, nearly coincides with his division between the Indo-Malayan and Austro-Malayan floras and faunas, the chief differences being the position of Sumbawa and Celebes. Both of these islands are excluded from the Papuasian realm, but included in the Austro-Malayan zoological and botanical regions."

In this connection it is unfortunate that Mr. Keane does not appear to have seen certain recent works, in which the right of Celebes to be included in the Orienta region is very strongly urged. Had he done so, he would have been able to point out an interesting coincidence between ethnographic and zoological boundaries.

Evidence in favour of another such coincidence is noticeable in the author's contention that Tibet is the cradle of the Mongol division of mankind, the mammals of that plateau being, as is well known, curiously different from those of adjacent districts. As Tibet slowly rose from a lower elevation in Pleistocene times, so, if we understand the author rightly, the Mongols gradually became differentiated from a more generalised human stock, subsequently to descend and pour over the lowlands to the south.

It seems partly due to this hypothesis that the author is strongly in favour of regarding the native races of America as entitled to form a distinct primary division of mankind, and not a part of the Mongoloid. He states, however ("Ethnology," p. 336), that "the American undoubtedly approximates nearest to the Mongol form, and as the latter cannot be derived from the former, it follows, as is now generally allowed, that the American type has been differentiated from a generalised Mongol prototype." This is really a distinction without a difference; and as we scarcely suppose that any anthropologist would derive Americans from the typical Mongol as we know him now, there seems little reason for departing from the view that the former are a branch of the Mongoloid division.

Even, however, in his own view, the author does not appear quite logical, for, after speaking of the above-mentioned close relationship of Americans and Mongols, on p. 353 of the present volume, he seeks to connect the Eskimo with the long-headed palæolithic man of Europe. Now, Sir William Flower, in his address to the Anthropological Institute in 1885, stated that "such scanty remains as have yet been discovered of the early inhabitants of Europe present no structural affinities to the Eskimo, although it is not unlikely that similar external conditions may have led them to adopt similar modes of life." This very definite statement requires refutation before the opposite view can be maintained; and then it has to be shown that the palæolithic long-head approximated to a Mongoloid type. Moreover, if he should be so proved, then he must apparently have been near to, if not the actual progenitor of, the typical Tibetan Mongol; and if so, how can the Eskimo and the Mongol be genetically separated?

In one other important point Mr. Keane also departs widely from the classification adopted by Sir William Flower. This is in regard to the peoples commonly called Polynesians, or Eastern Polynesians. These, which include the Samoans, Maori, Tongans, Tahitians, Marquesas Islanders, and Hawaians, together with some of the Fijians, are regarded by Sir William as an offshoot from the Mongolian stock, displaying evidence of a Melanesian crossing. Their resemblance to the Caucasic type has, writes Sir William,

"led some writers to infer a real extension of the Caucasian element at some very early period into the Pacific Islands, and to look upon their inhabitants as the product of a mingling of all three great types of men. Though this is a very plausible theory, it rests on little actual proof, as the combination of Mongolo-Malayan and Melanesian characters in different degrees, together with the local variations certain to arise in communities so isolated from each other and exposed to such varied conditions as the inhabitants of the Pacific Islands, would probably account for all the modifications observed among them."

This "very plausible theory" is adopted in its entirety by Mr. Keane; and, under the name of "Indonesians," we find the Polynesians on p. 562 of the volume before us definitely taking their place in the Caucasian division; the remark being added, that "their claim to belong to this connection can no longer be seriously questioned." In view of the passage quoted above, this statement appears to us decidedly too positive to be employed in a controversial case of this description. It is noteworthy that in the "Ethnology" these same "Indonesians," though considered of Caucasian origin, are still retained in the chapter devoted to Mongolians.

It may be added that in both volumes the amount of space devoted to the Polynesians is far too short, the Maori especially having only a very few lines assigned to them. Little is also said with regard to the Melanesians of Fiji; and we have been unable to discover a reference to the remarkable dolichocephalic development of the Kai Colo mountain tribes of those islands.

Further criticism is prevented by lack of space. We may accordingly conclude by the expression of our sense of the high value of Mr. Keane's work, which will be acceptable alike to the advanced student of ethnology and to all those interested in the natural history of their own race. The issue of a second edition of the "Ethnology" sufficiently vouches for the popularity of that volume. Should a new edition of both volumes be called for, we venture to think that if the author could see his way to combine and amalgamate them on the lines suggested above, a very admirable work would be presented in a form more convenient for general reference.

R. L.

## *PRACTICAL GEOMETRY.*

*Text-book of Practical Solid Geometry, &c., for the use of the Royal Military Academy, Woolwich.* By Captain E. H. de V. Atkinson, R.E. Pp. 116 + xvi plates. (London: E. and F. N. Spon, Ltd., 1899.)

*Geometrical Drawing for Army and Navy Candidates and Public School Classes.* By E. C. Plant, C.B. Vol. I. Practical Plane Geometry. Pp. xiv + 186. (London: Macmillan and Co., Ltd., 1899.)

THE characteristic deficiencies of English text-books are painfully conspicuous in most of the current works on practical geometry. Take a second-rate cookery-book, and shuffle the recipes at random; you will have a fair analogy to the quality and sequence of the books provided for the Army cadet or the Science and Art candidate. Assuredly they manage these things better in France. A century ago, Monge expounded the principles of the method of plan and elevation (*géométrie descriptive* as he called it) with a simplicity, clearness and order which have never been surpassed, although, no doubt, improvements in detail have been effected. The school which Monge created followed loyally in the steps of their master; and the consequence is that in France a student of civil or military engineering can attend a course or study a treatise on descriptive geometry which makes him familiar with a *method*, a system of elementary principles which he can apply to an endless variety of practical problems.

"Monge a souvent répété que, lorsqu'on savait les divers problèmes relatifs au point, à la droite et au plan, et dont l'ensemble forme ce que l'on appelle encore et assez improprement *les préliminaires de la géométrie descriptive*, on savait la géométrie descriptive."

So says Olivier in the preface to his excellent course published in 1843-4, and based upon lectures actually delivered in the École Centrale des Arts et Manufactures.

Accordingly, after a brief introduction, M. Olivier discusses the representation of the point, the straight line, and the plane, and the elementary problems relating to them. What is offered instead of this to the English student? Rules for finding the plan and elevation of an equilateral triangle, of a cube, octahedron, &c., in various specified positions, with a very few really fundamental problems apologetically inserted here and there. Now although the representation of a few concrete solids may be useful to help the beginner to see the object of orthogonal projection, a text-book wholly, or almost wholly, devoted to such special problems is of very little use, except for the passing of examinations set exclusively on these lines.

Similar remarks might be justly applied to most of our books on practical plane geometry and perspective. The almost invariable rule is to give a more or less numerous set of isolated examples, all worked out, with as little discussion of principles as possible: the result is that the student, instead of being provided with a powerful instrument capable of endless adaptation, is merely acquainted with a bundle of dry practical rules.

The works which have suggested these observations are by no means the worst of their class: on the contrary, they are much better than the average, and mark, it is to be hoped, a movement in the direction of reform.

Captain Atkinson's book is intended chiefly for the Royal Military Academy, and its scope has doubtless been dictated by this consideration. Its principal merit is that it contains three chapters on horizontal projection (*i.e.* the method of an indexed plan) which really do give a useful and practical outline of this method in an orderly way. Most of the elementary problems are solved, and the examples appear to be well chosen. It would have been a good plan to give the data of some unworked problems graphically instead of stating them all in words. The earlier part of the book is less attractive; it contains a bare outline of orthogonal projection and a few miscellaneous notes on regular solids, ways of drawing an ellipse, &c. The book ends with a sketch of the method of isometric projection. The plates are clear: unfortunately they are printed on folded sheets, and bound up at the end of the book; this makes it very difficult to follow a figure and the text relating to it simultaneously. If the plates were bound separately the convenience of the work would be greatly increased.

Mr. Plant discusses a great variety of problems, which have been arranged in groups in a fairly systematic way. The figures are from photographs of actual drawings by the author and his assistants, and so afford the student a real practical standard of accuracy. The book is likely to be very useful to the classes for whom it is intended: at the same time, there are several points on which it appears to us rather open to criticism.

In the first place, the attention given to different groups of problems is not proportional to their importance. At least half of the problems in sections G to K might have been set as exercises; this would have given space for a discussion of similar figures—an important subject almost ignored.

Again, the use of set squares for drawing parallels receives no attention, although these instruments are casually mentioned in the introduction. Nothing is more essential to the draftsman than familiarity with the use of set squares; compass constructions (such as those given in this book) for drawing parallels and perpendiculars are seldom used in practical work.

In a similar way, the use of the protractor for setting off angles is not sufficiently brought out. There is actually a section on the construction of certain special angles (such as $67^{\circ}\ 30'$) without a protractor. The section on regular polygons is specially unsatisfactory: there may be some sense in giving an accurate compass construction for a pentagon, but what earthly use is there in giving *incorrect* constructions (*e.g.* for the heptagon, p. 30 and elsewhere) which only afford an approximation obtainable much more simply by means of a protractor or scale of chords, or even by a method of trial? It may be added that these approximate constructions are given without any warning of their real inaccuracy.

Finally, there are a good many examples of no practical importance: for instance, group J is "To inscribe a square in all (!) the figures capable of containing it." Of course when questions of this kind turn up as Euclid riders, it is a good thing to make a schoolboy draw an accurate figure; but to include them in a text-book of practical geometry is waste of space.

The fact is that ideal treatises on practical geometry in all its branches, for the use of English students, have yet to be written. Ordinary plane geometry, orthogonal projection, perspective and projective geometry—all these are methods of extreme value, both to the mathematician and to the engineer, when they are really mastered; but a mere smattering is of very little use. Unless you know thoroughly the elementary principles involved, the solution of hundreds of isolated examples is little better than waste of time: here, as elsewhere, an ounce of theory is worth a ton of "practice" of the usual kind. Real practice, of course, is indispensable; but it should be systematic, and illustrate principles of general application. G. B. M.

## OUR BOOK SHELF.

*Michael Faraday: His Life and Work.* By Silvanus P. Thompson, D.Sc., F.R.S. Pp. ix + 308. "The Century Science Series." (London: Cassell and Co., Ltd., 1898.)

THE lives of men to whose genius and untiring devotion to research the stately edifice of modern science owes its existence, have a fascination and an interest which appeal to a much wider circle than that of the few who are able to realise the full significance of their epoch-making scientific discoveries. Even those to whom science is little more than a name are capable of feeling a keen interest in everything that concerns the purely human element in the lives of the great leaders in science. Hence there has arisen a demand for biographical literature of this type, a demand which the "Century Science Series," to which the volume before us is the latest addition, is intended to meet.

Of all the great names in the history of science which have become household words in civilised communities, that of Michael Faraday will always stand out pre-eminently as that of one in whom genius was wedded to a childlike simplicity and transparent sincerity of character but seldom found in association with such remarkable

powers of the intellect. Faraday's career was a truly remarkable one, judged from almost every point of view. Deprived of all the advantages of a careful training in early life, and commencing the study of science at an age when the deficiencies of early education are not easily remedied, he yet, by strenuous effort and single-minded devotion to a high ideal, succeeded in working his way to the very front rank of the scientific workers of his day. Again, although in his time electrical theory was being largely developed by the great French mathematicians, and mathematical analysis was regarded as an indispensible instrument of research, Faraday, without the use of a single symbol, succeeded in discovering those great fundamental facts on which the whole structure of modern electrical engineering rests, and in determining their exact quantitative relations; he further succeeded in explaining many obscure phenomena which had eluded the grasp of the great continental mathematicians. As Clerk Maxwell discovered, he was no mathematician, yet achieved results apparently only attainable by such methods.

In the small volume before us the account of Faraday's researches is admirably rendered, and is presented in a connected manner, which enables the reader to follow the trains of thought that suggested to Faraday many of his experiments. Of peculiar interest are those negative results which must now be regarded as dim foreshadowings of later discoveries—such as the attempt to discover whether a magnetic field had any effect on the refrangibility of light when applied to its source.

But interesting as is the account of Faraday's researches to those with a moderate knowledge of physics, the general reader will probably prefer to confine his attention to the earlier and later chapters in the book, in which Faraday is presented to us from the purely human standpoint. The extracts from his letters—some of which now appear for the first time—give us interesting glimpses of his inner life. His warm human sympathies, his delight in the beauties of nature, his deep and life-long attachment to his wife, his sturdy adhesion to the religious sect in which he had grown up, his relations to illustrious contemporaries—are all topics full of interest to the general reader; and they are handled in a manner well calculated to rivet his attention and enlist his sympathy. We congratulate Prof. S. P. Thompson on having successfully brought out and emphasised the quaker-like simplicity of Faraday's character, and the remarkable freedom from complexity in which he kept his life, notwithstanding the height of his fame.

*Untersuchungen über Strukturen.* By O. Bütschli. Pp. viii + 411; Atlas to ditto; Plates 27. (Leipzig: W. Engelmann, 1898.)

IN this work the author sets forth in great detail the results of investigations, extending over six years, upon the minute structure of various bodies, products, for the most part, of the activity of living organisms. The object of these researches was to extend, and to put to the test, certain conclusions reached by the author in 1892, in his well-known work on the structure and physical constitution of protoplasm. In an appendix to the work in question he gave an account of some observations upon the minute structure of certain substances, such as gelatine and egg albumen, which exhibit the phenomena of swelling or of coagulation, and came to the conclusion that these substances possessed a minute structure which was finely honeycombed or alveolar ("Wabig"). In the present work these observations are renewed and greatly extended, both as regards minuteness of detail and in the variety of material. Besides researches upon gelatinous and coagulable substances such as gelatine, celloidin, albumen, and so forth, the author has studied the minute structure of various sphærocrystals, of natural and artificial cellulose structures, of starch granules, and finally of a number of natural products of animal tissues, such as chitin envelopes, spongin fibres, matrix of hyaline cartilage, and other similar structures.

To give an adequate account of these exhaustive researches, which cover more than 400 pages in the setting forth, is impossible in a short space; and it is to be regretted that the author has not anywhere given for the benefit of his readers a general summary or review of the results obtained by him. The book is, in fact, a collection of separate investigations, of which preliminary accounts have already appeared during the past seven years, bound up with an introduction and two discussions. In the introduction, the author gives an account of the order and sequence of his researches, and describes his methods of investigation, especially with regard to the technique of micro-photography. The two discussions deal with the question of the reality of the structural images obtained with the highest magnifications, and with certain phenomena of polarisation. On the other hand, the many interesting and important results obtained by the author have to be sifted out by the reader from a great mass of facts and arguments, which is no easy matter for those not specially conversant with the subject. It may be briefly stated, however, that in all the substances investigated Bütschli finds a distinct alveolar structure, which in the case of coagulable bodies is of the nature of a true foam ("Schaumig-wabig"), but which in crystallisable or sphæro-crystalline bodies is composed of an aggregation of minute globulites ("Globulitisch-wabig"). Amongst the many interesting facts which the author brings forward, attention may be specially drawn to his observations upon colloids, which when fixed in a state of tension develop appearances very similar to those seen in karyokinetic figures, suggesting the conclusion that the nuclear spindle is an expression of the effects of tension, rather than of actual differences of material between filar and interfilar substance. The author's results are supported by an atlas containing twenty-seven plates of beautifully executed micro-photographs, as well as by numerous figures in the text. All those who are interested in this very important field of investigation, to which Bütschli has devoted so many years of patient and laborious research, will welcome the appearance of this work, constituting as it does a solid contribution of facts which cannot lightly be brushed aside by those who may be opposed to his theories. E. A. M.

*A Manual of Library Cataloguing.* By J. Henry Quinn, Librarian Chelsea Public Libraries. Pp. 164. (London: Library Supply Company, 1899.)

THIS book is in several respects favourably distinguished from others of its class that have recently seen the light. The animosities of the library world are not imported into its pages, and in several ways the writer deprecates the subordination of practical common sense to a display of learning. He does not, for instance, condemn the unfortunate reader in search of the works of George Sand to remember that her real name was Dudevant, and to look under that heading. The book is avowedly not designed for workers in a learned institution, but is most admirably adapted for those engaged in cataloguing the contents of an ordinary library. Mr. Quinn's rules are set forth with singular clearness, and endowed with a wise elasticity. He is on the whole in favour of the "dictionary" system, wherein each book may be found, under a single alphabetical arrangement, under its title, the name of its author, and the particular portion of human knowledge with which it deals, but he also gives an adequate account of the system of "classified catalogues." An appendix gives most valuable help to the librarian in his dealings with the printer of his catalogue, and gives completeness to a most valuable little work.

## LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### Strawberry Cure for Gout.

THE season of strawberries is at hand, but doctors are full of fads, and for the most part forbid them to the gouty. Let me put heart into those unfortunate persons to withstand a cruel medical tyranny by quoting the experience of the great Linnæus. It will be found in the biographical notes, written by himself in excellent dog-latin, and published in the Life of him by Dr. H. Stoever, translated from German into English by Joseph Trapp, 1794. Linnæus describes the goutiness of his constitution in p. 416 (*cf.* p. 415), and says that in 1750 he was attacked so severely by sciatica that he could hardly make his way home. The pain kept him awake during a whole week. He asked for opium, but a friend dissuaded it. Then his wife suggested, "Won't you eat strawberries?" It was the season for them. Linnæus, in the spirit of an experimental philosopher, replied, "*tentabo*—I will make the trial." He did so, and quickly fell into a sweet sleep that lasted two hours, and when he awoke the pain had sensibly diminished. He asked whether any strawberries were left: there were some, and he eat them all. Then he slept right away till morning. On the next day he devoured as many strawberries as he could, and on the subsequent morning the pain was wholly gone, and he was able to leave his bed. Gouty pains returned at the same date in the next year, but were again wholly driven off by the delicious fruit; similarly in the third year. Linnæus died soon after, so the experiment ceased.

What lucrative schemes are suggested by this narrative. Why should gouty persons drink nasty waters, at stuffy foreign Spas, when strawberry gardens abound in England? Let enthusiastic young doctors throw heart and soul into the new system. Let a company be run to build a Curhaus in Kent, and let them offer me board and lodging gratis in return for my valuable hints.

F. G.

### Distant Sounds.

WHEN the Prince of Wales reviewed great squadrons at the Jubilee review, only one gentleman from Wimbledon, and myself, recorded hearing the salutes near London. I think it worth while, therefore, to note that what seemed to be the thumping sound of heavy guns was to be heard here to-day, from half-past five to a quarter to six p.m., Greenwich time; and even *felt* in the chest.

Some of your other correspondents may be able to tell where the guns—if guns—were fired. The importance of the subject seems to require no remark from me.

I sit in a one-storied building, as far remote from street noises, perhaps, as is possible in London, except in one or two great private gardens, or in the parks. No road is within fifty feet of me; and I know all my neighbours' noises, and have been used to the sound of old-fashioned guns up to 1894.

W. F. SINCLAIR.

102 Cheyne Walk, Chelsea, London, S.W., June 2.

## THE JUBILEE OF SIR GEORGE GABRIEL STOKES.

THE close of the present Easter term coincides with the end of the fiftieth year of the tenure by Sir George Gabriel Stokes of the Lucasian Professorship at Cambridge. Born in 1819, the same year as our Sovereign, he entered Pembroke College the year of Queen Victoria's Accession. In 1841 he took his degree as Senior Wrangler, the earliest of the wonderful group of Cambridge mathematicians—Stokes, Cayley, Adams—who occupied that position in three successive years. It has been one of the most pleasing features of the recent jubilee that Mr. H. Cadman Jones, who was second to Stokes both in the Mathematical Tripos and in the contest for the Smith's Prize, has been able to come to Cambridge to offer his congratulations to his old friend and competitor.

In the long history of the University several chairs have been held by the same professor for more than fifty years. Prof. R. Plumtre, of Queens', was Regius Professor of Physic from 1741 to 1793; Thomas Martyn, of Sidney Sussex, was Professor of Botany from 1761 to 1825; and Adam Sedgwick held the Woodwardian Chair of Geology from 1818 to 1873; but this is the first time in the history of the University that the occasion has been officially celebrated.

In the course of his long life Sir George Stokes has been first Secretary and later President of the Royal Society. He presided over the British Association in 1869. He represented the University in Parliament from 1887 to the dissolution in 1891, and was created a baronet in 1889. He has received the Rumford and the Copley medal from the Royal Society, and is a D.C.L. of Oxford, a LL.D. of Cambridge, Edinburgh and Dublin, and a ScD. of Cambridge. Amongst the numerous honours which have been showered upon him from abroad, he is a Knight of the Prussian order "Pour le Mérite," a distinction he shares with but four or five at most of his countrymen.

This is not the place to enumerate or appreciate the vast volume of published work which Prof. Stokes has produced within the last fifty years. A quarter of a century ago one of his most distinguished pupils, Prof. Tait, attempted in these pages to give some account of the magnificent series of papers we owe to Sir George. The portrait which accompanied Prof. Tait's article is still strikingly like the original; it seems strange that five-and-twenty years should have left so little trace in those finely-moulded features.

The celebration of the jubilee commenced with the delivery of the Rede Lecture by Prof. Cornu, of the École Polytechnique of Paris. The subject of the lecture was "The Wave Theory of Light, its Influence on Modern Physics." The endowment of this lecture was left to the University as long ago as 1524 by Sir Robert Rede, Lord Chief Justice in Henry VIII.'s reign, and this is the first time that it has been delivered by a foreigner. Prof. Cornu spoke in French, and both the brilliancy of his matter and the charm of his elocution made a deep impression on his audience. Prof. Cornu, in mentioning the works of Newton, Young, Clerk Maxwell, Rayleigh, Kelvin and Stokes, paid a splendid tribute to those mathematical studies which have ever been the chief glory of Cambridge.

Sir George Stokes's College, Pembroke, entertained a distinguished company at dinner on Thursday evening. The delegates from the various Universities and learned Societies were present, and many of the former members of the Society assembled to do honour to their most distinguished graduate. As it was necessary for the company to adjourn at nine o'clock to the Fitzwilliam Museum, there were no speeches, but the health of Sir George was drunk amidst a scene of rare enthusiasm.

The Fitzwilliam Museum is admirably adapted for the purposes of an evening reception. Lit up by electric light, the walls of its spacious galleries hung with pictures, and its floor covered with a crowd dressed in the robes of the various institutions that had sent delegates, it presented a most brilliant spectacle. The guests were received by the Vice-Chancellor, supported by his Esquire Bedells. During the course of the evening a bust of Sir George Stokes, executed by Mr. W. Hamo Thornycroft, was presented to Pembroke College, and a replica was at the same time given to the University. Lord Kelvin, on behalf of the subscribers, presented the busts, and in doing so he remarked that the assembly was taking part in the celebration of a great man and of natural philosophy in the University of Cambridge—natural philosophy in the broadest sense of the term, of which foundations had been laid by Sir George Stokes that would render the nineteenth century memorable in future

centuries. Sir George Stokes commenced as an undergraduate in Pembroke College: his first experimental work was made when he was a junior Fellow. He (Lord Kelvin) well remembered that in Pembroke College there were no physical laboratories, and the first physical laboratory in European Universities, he believed—certainly in these islands—was in Sir George Stokes's rooms, which he occupied as a junior Fellow about the year 1840 to 1843. If they considered the condition of natural philosophy in 1840 and in the present year, they might form some idea of how vast had been the results of his labours. Lord Kelvin pointed out that Sir George Stokes had the courage and spirit to take up subjects absolutely beyond the range of all the mathematicians of his age. Sound, light, elasticity, mathematical problems on the one hand, properties of matter on the other, were his studies, and the results had been of splendid benefit to the world of science. To him was due the credit for having published in lectures, if not in print, the grand theory of spectrum analysis. But his published papers contained but a small part of the work he had done for science. All workers in science in the University of Cambridge, all the communicators of papers to the Royal Society during the thirty years he was Secretary and the five years he was President, would agree with him in saying that Sir George Stokes had published in his own name but a very small part of the good he had done to the world. There was a debt of gratitude due to him, not only for what he had published, but for what he had done for others. He had published papers, and the discoveries contained therein had produced a monument more enduring than marble. But, still, they would like to have a marble monument, a tangible and visible sign for the men who knew him and the work he had done; and, therefore, it was a great privilege indeed to be allowed to unveil the two busts, one designed for the University of Cambridge and the other for Pembroke College.

The busts were received by the Vice-Chancellor on behalf of the University and—in the absence, through ill-health, of the Master—by the Rev. C. H. Prior, Senior Tutor of Pembroke, on behalf of the College. We are informed that Mr. Hamo Thornycroft will undertake the production of bronze copies of his bust of Sir George Stokes, about one-third of the size of the original, at a cost of seven guineas each, in case more than twenty-five are ordered. Names will be received by Sir William Crookes, 7 Kensington Park Gardens, W., and by Prof. Perry, Royal College of Science, S.W.

On Friday, June 2, the more important functions of the jubilee took place. At 11 a.m. the delegates were received by the Vice-Chancellor in the Senate House, and in the chronological order of the foundation of the institutions they represented, they tendered their addresses of congratulation to Sir George Stokes. The name of each delegate and of the institution he represented was announced by Mr. J. W. Clark, the Registrary. The delegate then advanced and presented his address to the Vice-Chancellor, who handed it to Sir George Stokes. At the close of the presentation Sir George, in a short speech, said he often thought in reviewing a long life that he might have worked harder, and he attributed his longevity to his "comparative idleness," a sentiment which found considerable favour with the undergraduates in the gallery.

The presentation commenced with the delegates from the University of Paris, and the following is a list of the institutions represented and of those chosen to represent them:—

University of France—Prof. Gaston Darboux, Doyen de la Faculté des Sciences.

University of Oxford—Sir William Reynell Anson, Bart., M.P., and Robert Edward Baynes, M.A., Lee's Reader in Physics.

University of St. Andrews—P. R. Scott Lang, M.A., Regius Professor of Mathematics.

University of Glasgow—Very Rev. Robert Herbert Story, D.D., Principal, and Lord Kelvin, M.A., Hon. LL.D., G.C.V.O.

University of Aberdeen—Sir William Duguid Geddes, LL.D., Principal.

University of Edinburgh—George Chrystal, M.A, Professor of Mathematics, and G. F. Armstrong, M.A., Professor of Engineering.

University of Dublin—George Salmon, D.D., Provost, and Benjamin Williamson, M.A., D.Sc.

Royal Society—Lord Lister, Hon. LL.D., President; Alfred Bray Kempe, M.A., Treasurer; Michael Foster, M.A., Professor of Physiology; Arthur William Rücker, M.A. (Oxon.), Professor of Physics, Royal College of Science, Secretaries.

Académie des Sciences, Paris—Prof. Becquerel.

Königliche Akademie der Wissenschaften, Berlin—Friedrich Kohlrausch, Director of the Physikalisch Technische Reichsanstalt, Charlottenburg.

Gesellschaft der Wissenschaften zu Göttingen—Edward Riecke, Professor of Physics.

New York, Columbia University—Robert S. Woodward, Ph.D., Professor of Mechanics and Mathematical Physics, Dean of the Faculty of Pure Science.

Princeton University, New Jersey—Prof. Edgar Odele Lovett.

Bataafsch Genootschap voor Physika, Rotterdam—Dr. Elie van Rijckevorsel.

Académie Royale des Sciences des Lettres et des Beaux Arts de Belgique—Prof. Alphonse Rénard, Prof. G. Van der Mensbrugghe.

Manchester Literary and Philosophical Society—Reginald Felix Gwyther, M.A., Sen. Sec.

Royal Irish Academy—Earl of Rosse, K.P., President, George F. FitzGerald, M.A., Professor of Natural and Experimental Philosophy, Trinity College, Dublin.

Royal Society of Edinburgh—Lord Kelvin, M.A., Hon. LL.D., President, and Sir John Murray, K.C.B., Hon. Sc.D.

St. Edmund's College, Ware—Right Rev. J. L. Patterson, M.A. (Oxon.), Titular Bishop of Emmaus.

École Polytechnique—Prof. Cornu and Prof. Becquerel.

École Normale Supérieure—Mons. Borel, Professor of Mechanics and Astronomy.

Royal Institution—Sir J. Crichton Browne, M.D. (Edinb.), Treasurer.

Philosophical Society of Glasgow—Lord Blythswood.

Cambridge Philosophical Society—Joseph Larmor, M.A., President.

Royal Astronomical Society—George Howard Darwin, M.A., Plumian Professor of Astronomy, President.

McGill University, Montreal—Lord Strathcona and Mount Royal, Hon. LL.D., G.C.M.G., High Commissioner in Great Britain of the Dominion of Canada, Henry Taylor Bovey, M.A., Professor of Engineering.

University of Toronto—R. Ramsay Wright, M.A., B.Sc., Professor of Biology.

St. David's College, Lampeter—A. W. Scott, M.A., Trinity College (Dubl.), Professor of Physical Science and Mathematics.

Institution of Civil Engineers—William Henry Preece, C.B., President.

King's College, London—Archibald Robertson, D.D. (Durham), Principal.

British Association—Sir William Crookes, President.

University of Durham—Ralph Allen Sampson, M.A., Professor of Mathematics.

Cambridge Ray Club—Alfred Newton, M.A., Professor of Zoology and Comparative Anatomy.

London Chemical Society—Dr. T. E. Thorpe.

Queen's College, Belfast—Thomas Hamilton, D.D., President.

Queen's College, Galway—Alexander Anderson, M.A., President.

University of Sydney—Philip Sydney Jones, M.D. (Lond.), Fellow of the Senate of the University of Sydney.

Royal College of Science, London—John Wesley Judd, C.B. LL.D., Dean; W. A. Tilden, Professor of Chemistry.

The Owens College, Manchester—Alfred Hopkinson, Q.C., M.A., Principal.

Royal Academies of Sciences of Amsterdam—J. D. van der Waals, Professor of Experimental Physics.

University of Bombay—Dr. H. M. Birdwood, M.A., C.S.I.
University of Calcutta—Hon. J. O'Kinealy, M.A , Judge of H.M.'s High Court of Bengal.
University of Madras—Hon. H. H. Shephard, M.A., Puisne Judge of the High Court of Madras.
London Mathematical Society—Lord Kelvin, M.A., Hon. LL.D., President.
University of Tokio, Keishiro Matsui, Chargé d'Affaires, Japanese Legation, London.
University of New Zealand—Edward John Routh, M.A., Sc.D.
Durham College of Science, Newcastle-on-Tyne—Henry Palin Gurney, M.A., Principal.
University of Adelaide—Horace Lamb, M.A., Professor of Mathematics in Owens College, Manchester.
University College of Wales, Aberystwyth—Robert Davies Roberts, M.A.
Yorkshire College, Leeds—Leonard J. Rogers, M.A., Professor of Mathematics.
Physical Society of London—Oliver J. Lodge, D.Sc., Professor of Physics, University College, Liverpool, President.
Mason College, Birmingham—John Henry Poynting, Sc.D., Professor of Physics.
Baltimore (Johns Hopkins)—Simon Newcomb, Hon. Sc.D., LL.D., Professor of Mathematics and Astronomy; and Professor Ames.
Firth College, Sheffield—William Mitchinson Hicks, Sc.D., Principal.
University College, Bristol—Frank R. Barrell, M.A., Professor of Mathematics.
City and Guilds of London Institute for Advancement of Technical Education—Sir Frederick Abel, Bart.
University College, Dundee—John Yule Mackay, Principal.
University College, Nottingham—John Elliotson Symes, M.A., Principal.
Victoria University—Nathan Bodington, Litt.D., Vice Chancellor.
Royal University of Ireland—Right Rev. Monsignor Molloy, D.D., D.Sc.
Royal College of Science for Ireland—Walter Noël Hartley, Professor of Chemistry.
University College, Liverpool—Richard Tetley Glazebrook, M.A., Principal.
University of the Punjab—Sir Charles Arthur Roe, M.A., late First Judge of the Chief Court, Punjab; late Vice-Chancellor of the University.
University College of South Wales, Cardiff—H. W. Lloyd Tanner, M.A. (Oxon.), Professor of Mathematics.
University College of North Wales, Bangor—Henry R. Reichel, M.A. (Oxon.), Principal.
Royal Indian Engineering College, Coopers Hill—Prof. A. Lodge, M.A. (Oxon.), Professor of Mathematics
University of Allahabad—G. Thibaut, Ph.D., Principal of the Muir Central College, Allahabad.
University of Wales—J. Viriamu Jones, M.A., Vice-Chancellor.

In addition to the delegates officially appointed, the University entertained a number of distinguished guests, amongst whom the names of the following may be mentioned:—

Captain Abney, C.B., S. Kensington; Prof. W. G. Adams, King's College, London; Prof. H. E. Armstrong, City and Guilds Institute, S. Kensington; Prof. Arrhenius, Stockholm; Prof. Ayrton, City and Guilds Institute, S. Kensington; Prof. Barker, University of Pennsylvania, Philadelphia, U.S.A.; Mr. Shelford Bidwell; Dr. Bottomley, The University, Glasgow; Mr. C. V. Boys, London; Sir Frederick Bramwell, Bart.; Dr. Haig Brown; Prof. W. Burnside, Greenwich; Prof. Clifton, Oxford; Prof. Egoroff, St. Petersburg; Prof. Esson, Oxford; Sir John Evans, K.C.B.; Prof. Carey Foster, London; Dr. F. Galton; Sir A. Geikie; Prof. Andrew Gray, Bangor; Prof. Hele-Shaw; Mr. Hubert Herkomer, R.A.; Sir J. D. Hooker, C.B., G.C.S.I.; Prof. J. Joly, Dublin; Prof. Kayser, Bonn; the Hon. Sir W. R. Kennedy; Sir J. Norman Lockyer, K.C.B.; Major P. A. MacMahon; Prof. van der Mensbrugge, Ghent; Prof. Michelson, Chicago; Prof. G. M. Minchin, Coopers Hill; Prof. G. Mittag-Lefller, Stockholm; Mr. Ludwig Mond; Mr. J. Fletcher Moulton, M.P., Q.C.; Prof. Nernst, Göttingen; Prof. Karl Pearson, University College, London; Prof. Perry, Royal College of Science; Sir John Phear; Prof. Quincke, Heidelberg; Lord Rayleigh, Lord Lieutenant of Essex; Prof. H. F. Reid, Baltimore; Prof. Osborne Reynolds, Manchester; Sir W. C. Roberts-Austen, K.C.B., Royal College of Science, London; Sir Henry E. Roscoe, Vice-Chancellor of the University of London; The Rev. Dr. Salmon, Provost of Trinity College, Dublin; Prof. Schuster, Manchester; Sir R. Strachey, G.C.S.I.; Mr. J. W. Swan; Mr. H. Thornycroft, R.A.; Prof. H. H. Turner, Oxford; Prof. Voigt, Göttingen; Rt. Rev. Lord Bishop of Wakefield; Rear-Admiral Sir William Wharton, K.C.B.; Sir W. H. White, K.C.B.

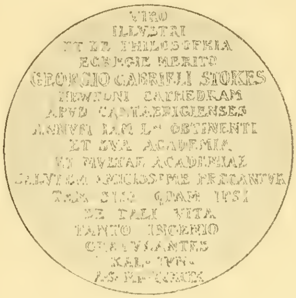
At 1.30 the Vice-Chancellor gave a lunch at Downing College to some 400 of the delegates and their hosts, and at 2.45 a congregation was held in the Senate House at which his Grace the Chancellor presided. The following address from the University was then read by Dr. Sandys, the Public Orator, and presented to Sir George Stokes, accompanied by a gold medal struck to commemorate the occasion.

Quod per annos quinquaginta inter nosmet ipsos Professoris munus tam praeclare ornavisti, et tibi, vir venerabilis, et nobis ipsis vehementer gratulamur. Iuvat vitam tam longam, tam serenam, tot studiorum fructibus maturis felicem, tot tantisque honoribus illustrem, tanta morum modestia et benignitate insignem, hodie paulisper contemplari. Anno eodem, quo Regina nostra Victoria insularum nostrarum solio et sceptro potita est, ipse eodem aetatis anno Newtoni nostri Universitatem iuvenis petisti, Newtoni cathedram postea per decem lustra ornaturus, Newtoni exemplum et in Senatu Britannico et in Societate Regia ante oculos habiturus, Newtoni vestigia in scientiarum terminis proferendeis pressurus et ingenii tanti imaginem etiam nostro in saeculo praesentem redditurus. Olim studiorum mathematicorum e certamine laurea prima reportata, postea (ne plura commemoremus) primum aquae et immotae et turbatae rationes, quae hydrostatica et hydrodynamica nominantur, subtilissime examinasti; deinde vel aquae vel aeris fluctibus corporum motus paulatim tardatos minutissime perpendisti; lucis denique leges obscuras ingenii tui lumine luculenter illustrasti. Idem etiam scientiae mathematicae in puro quodam caelo diu vixisti, atque hominum e controversiis procul remotus, sapientiae quasi in templo quodam sereno per vitam totam securus habitasti. In posterum autem famam diuturnam tibi propterea praesertim auguramur, quod, in inventis tuis pervulgandis perquam cautus et consideratus, nihil praeproperum, nihil immaturum, nihil temporis cursu postea obsolefactum, sed omnia matura et perfecta, omnia omnibus numeris absoluta, protulisti. Talia propter merita non modo in insulis nostris doctrinae sedes septem te doctorem honoris causa nominaverunt, sed etiam exterae gentes honoribus eximiis certatim cumulaverunt. Hodie eodem doctoris titulo studiorum tuorum socios nonnullos exteris e gentibus ad nos advectos, et ipsorum et tuum in honorem, velut exempli causa, libenter ornamus. In perpetuum denique observantiae nostrae et reverentiae testimonium, in honorem alumni diu a nobis dilecti et ab aliis nomismate honorifico non uno donati, ipsi nomisma novum cudendum curavimus. In honore nostro novo in te primum conferendo, inter vitae ante actae gratulationes, tibi omnia prospera etiam in posterum exoptamus.

The medal was designed by Mr. De Saulles, who designed the jubilee medals, and bears the head of the recipient in profile on the obverse, and some lines in Latin written by the Master of Trinity on the reverse. By the courtesy of the University Press, we are able to give the accompanying illustrations of the medal. The likeness is remarkably good, and the medal, replicas of which, in bronze, will be presented to the official delegates, was universally admired. We are informed that copies in bronze of the medal may be obtained from Messrs. Macmillan and Bowes. The number of medals struck is limited.

After the medal had been presented to Sir George by the Chancellor, Prof. Cornu advanced and presented on behalf of the Institute of France a copy of the Arago medal in gold. Immediately after the ceremony, honorary degrees of Doctor of Science were

conferred upon the following distinguished visitors :—Prof. M. A. Cornu, Member of the Institute of France, Professor of Experimental Physics in the École Polytechnique of Paris ; Prof. J. G. Darboux, Member of the Institute of France and Professor of Higher Geometry in the University of Paris ; Prof. A. A. Michelson, Professor of Experimental Physics in the University of Chicago ; Prof. M. G. Mittag-Leffler, Professor of Pure Mathematics at Stockholm ; Prof. G. H. Quincke, Professor of Experimental Physics in the University of Heidelberg ; and Prof. W. Voigt, Professor of Mathematical Physics in the University of Göttingen. Prof. F. W. G. Kohlrausch, Director of the Physikalisch-Technische Reichstanstalt, Charlottenburg, was unfortunately deterred by illness from attending to receive the degree which the University had been anxious to confer upon him.




The Stokes Jubliee Medal.

The following are the speeches delivered by the Public Orator in presenting to his Grace the Chancellor the several recipients of the honorary degree.

(1) PROF. CORNU (PARIS).

Primum vobis praesento artium plurimarum Scholae Parisiensis professorem, quem in hoc ipso loco die hesterno perspicuitate solita disserentem audivistis, virum non modo solis de lumine in partes suas solvendo, sed etiam orbis terrarum de mole metienda per annos plurimos praeclare meritum. Lucis in natura explicanda, quanta cum doctrinae elegantia, quanta cum experimentorum subtilitate, quam diu versatus est. Idem quam accurate velocitatem illam est dimensus, qua per aeris intervallum immensum lucis simulacra minutissima transvolitant,

"suppeditatur enim confestim lumine lumen,
et quasi protelo stimulatur fulgere fulgur."

Lucis transmittendae in λαμπαδηφορίᾳ quam feliciter lampada a suis sibi traditam ipse etiam trans aequor Atlanticum alii tradidit.

(2) PROF. DARBOUX (PARIS).

Sequitur deinceps vir insignis Nemausi natus, Parisiensium in Universitate illustri geometriam diu professus et scientiarum facultati toti praepositus. Peritis nota sunt quattuor illa volumina, in quibus superficierum rationem universam inclusit ; etiam pluribus notum est, quantum patriae legatus deliberationibus illis profuerit, quae a Societate nostra Regia primum institutae, id potissimum spectant, ut omnibus e gentibus quicquid a scientiarum cultoribus conquiritur, indicis unius in thesaurum, gentium omnium ad fructum, in posterum conferatur. Incepto tanto talium virorum auxilio ad exitum perducto, inter omnes gentes ei qui rerum naturae praesertim scientiam excolunt, sine dubio vinculis artioribus inter sese coniungentur.

(3) PROF. MICHELSON (CHICAGO).

Trans aequor Atlanticum ad nos advectus est vir insignis, qui ea quae professor noster Lucasianus de aetheris immensi regione, in qua lux propagatur, orbis terrarum motu perturbata, olim praesagiebat, ipse experimentis exquisitis adhibitis penitus exploravit. Lucis explorandae in provincia is certe scientiarum inter lumina numeratur, qui olim fratrum nostrorum transmarinorum in classe non ignotus, lampade trans oceanum e Gallia sibi tradita feliciter accepta, etiam exteris gentibus subito affulsit, velocitatem immensam eleganter dimensus, qua lucis fluctus videntur (ut Lucretii verbis utar)

"per totum caeli spatium diffundere sese,
perque volare mare ac terras, caelumque rigare."

(4) PROF. MITTAG-LEFFLER (STOCKHOLM).

Scandinavia ad nos misit scientiae mathematicae professorem illustrem, qui studiorum suorum velut e campo puro laudem plurimam victor reportavit. Idem Regis sui auspiciis, qui praemiis propositis magnum huic scientiae attulit adiumentum, etiam exterarum gentium ad communem fructum prope viginti per annos Acta illa Mathematica edidit, quae in his studiis quasi gentium omnium internuntium esse dixerim. Ipse Homerus (ut Pindari versus verbo uno tantum mutato proferam) ἄγγελον ἐσλὸν ἔφα τιμὰν μεγίσταν πράγματι παντὶ φέρειν· αὔξεται καὶ Μάθησις δι' ἀγγελίας ὀρθᾶς.

(5) PROF. QUINCKE (HEIDELBERG).

Universitatem Heidelbergensem abhinc annos quadraginta professorum par nobile spectroscopo invento in perpetuum illustravit. Adest inde discipulorum plurimorum in scientia physica praeceptor, qui et in instrumentis novis inveniendis sollertiam singularem et in eisdem adhibendis industriam indefessam praestitit. Ei qui in scientiae physicae ratione universa versati, viri huiusce inventis utuntur, etiam de sua scientia verum esse confitebuntur, quod de arte oratoria praesertim dixit Quintilianus :—"in omnibus fere minus valent praecepta quam experimenta."

(6) PROF. VOIGT (GÖTTINGEN).

Universitatem Goettingensem, a Rege nostro Hanoveriensi Georgio secundo conditam, vinculo non uno cum Universitate nostra coniunctam esse constat. Constat eandem etiam per annos prope quinquaginta Caroli Frederici Gaussii, scientiae mathematicae et physicae professoris celeberrimi, gloria esse illustratam, qui cum ingenio fecundissimo disserendi genus consummatum coniunxit. Iuvat inde professorem ad nos advectum excipere, qui scientiae eiusdem pulcherrimam nactus provinciam, etiam lucem ipsam et crystalla ingenii sui lumine illustravit.

After the congregation, a garden party was held in the beautiful old gardens of Pembroke College, where a numerous and brilliant company assembled and listened to the music of the Royal Artillery Band.

In the evening, a dinner, at which were present some 220 of the guests of the University and their hosts, took place in Trinity College Hall. His Grace the Duke of Devonshire presided, and after the health of the Queen had been drunk he proposed, in a felicitous speech, the health of the hero of the day. The toast was drunk with the greatest enthusiasm. The only other toasts were "The Guests," proposed by Prof. George Darwin, and responded to by Lord Lister ; and "The Chancellor," proposed by the Vice-Chancellor. In responding, the Chancellor thanked the Master and Fellows and Trinity

for their hospitality in granting the use of the Hall, and Dr. Butler replied on behalf of the College.

In addition to the guests who were more directly associated with the celebration of the jubilee, the following were present at the banquet:—Mr. Justice Mathew, the High Sheriff of Cambridgeshire, the Lord Lieutenant of Cambridgeshire, the Bishop of Ely, the Right Hon. A. J. Balfour, and many other distinguished guests.

This dinner brought the official proceedings to an end, but on Monday a meeting of the Philosophical Society was held for the presentation of papers to be published in a special volume of the Society's *Transactions* commemorative of the long connection of Sir G. G. Stokes with the Society. The following are amongst those who formally communicated papers:—

I. By Prof. M. G. Mittag-Leffler: On the analytical representation of a uniform branch of a monogenic function.
II. By Prof. H. Poincaré: The theory of groups.
III. By Dr. L. Boltzmann:
IV. By Prof. A. Righi:
V. By Prof. A. A. Michelson: On the echelon spectroscope.
VI. By Major P. A. Macmahon, R.A.: Application of the partition analysis to the study of the properties of any system of consecutive integers.
VII. By Lord Kelvin: On diffraction of solitary waves.
VIII. By Prof. A. Schuster: On the periodogram of magnetic declination derived from twenty-five years' observations at the Greenwich Observatory.
IX. By Prof. W. D. Niven: A general method of determining free electric distributions by successive approximations.
X. By Prof. G. D. Liveing: The influence of temperature on the absorption spectra of salts.
XI. By Prof. A. R. Forsyth: On the integrals of systems of differential equations.
XII. By Mr. J. Larmor: On the general theory of the optical relations of magnetism.

Together with papers by Prof. J. J. Thomson, Dr. E. W. Hobson, Mr. E. H. Griffiths, Mr. W. N. Shaw, Mr. E. W. Brown, and Mr. H. M. Macdonald.

In conclusion, it may be stated that from beginning to end the celebration was a complete success. The weather played an important part in securing this success, but the thanks of all who assisted at the jubilee must also be tendered to those at Cambridge who took such careful forethought for their convenience and comfort.

*The Cambridge Review* for June 1 publishes several contributions referring to the jubilee, and issues as a special supplement an excellent portrait of Sir George Stokes. Prof. J. J. Thomson gives an appreciative account of the scientific career and work of the esteemed Lucasian Professor. In concluding the article, he remarks:—

"By his researches on hydrodynamics he has founded a new branch of the science; in optics he has, to use the words of Lord Kelvin, been the teacher and guide of his contemporaries; he was the first to enunciate in his lectures the principles on which spectrum analysis is founded; he unravelled the laws of fluorescence; he investigated the variation of gravity over the surface of the earth; he has solved problems of the greatest difficulty in pure mathematics; while the latest of his long series of researches is his remarkable paper on the nature of the Röntgen rays. His papers are the classics of science; they are remarkable, not only for the results obtained, but also for their perfect clearness of expression and thought, for the elegance of the mathematical methods, for their maturity of judgment and for that care and finish on which so much of the impressiveness of a paper depends.

The little more and how much it is,
The little less and what worlds away.

These researches show the combination of supreme mathematical and experimental power; with simple apparatus and without the appliances which are now at the command of physicists, he has made experiments which have settled some of the most crucial points in optics, and which will be quoted as long as science exists. The rooms in Pembroke, where he made many of his experiments, will in the history of science and of the University be associated with those in the Old Court of Trinity, where Newton made the prism reveal the nature of white light. And, indeed, there are many points of resemblance between the careers of Newton and of Stokes: both held the Lucasian Professorship, both were Presidents of the Royal Society, both represented the University in Parliament; and the resemblance is not confined to the offices they held, it extends to their type of mind. Often, in reading Stokes's papers, we feel this is just how Newton would have treated this point, these are the deductions which Newton would have drawn."

Prof. Jebb contributes the following ode to the *Cambridge Review*.

To Sir George Gabriel Stokes.

June 1, 1899.

Clear mind, strong heart, true servant of the light,
True to that light within the soul, whose ray,
Pure and serene, hath brightened on thy way,
Honour and praise now crown thee on the height
Of tranquil years. Forgetfulness and night
Shall spare thy fame, when, in some larger day
Of knowledge yet undream'd, time makes a prey
Of many a deed and name that once were bright.

Thou, without haste or pause, from youth to age,
Hast moved with sure steps to thy goal. And thine
That sure renown which sage confirms to sage,
Borne from afar. Yet wisdom shows a sign
Greater, through all thy life, than glory's wage;
Thy strength has rested on the Love Divine.

## CENTENARY OF THE ROYAL INSTITUTION.

The celebration of the centenary of the foundation of the Royal Institution was commenced on Monday by a banquet given by the managers of the Institution in the Hall of the Merchant Taylors' Company. The Duke of Northumberland, president of the Institution, occupied the chair. The Prince of Wales was present, and a number of distinguished men of science were among the guests. Reference to a few points connected with the history and work of the Institution were made in the course of the evening. In acknowledging the toast of his health, the Prince of Wales said:

I consider it a great privilege and honour to take part, as vice-patron of this Institution, in the celebration of its 100th anniversary. I had an early acquaintance with the Royal Institution. Although it is nearly half a century ago, I have not forgotten that just after Christmas my brother, the Duke of Coburg, and myself were sent to attend the lectures given by the great Prof. Michael Faraday. I have not forgotten the clear way in which Prof. Faraday explained difficult scientific problems, and showed the chemical experiments which were then the order of the day. Among the most remarkable discoveries with which the Institution is associated is that of Davy, which has saved thousands of lives. It is needless to speak of the researches of Faraday, whom I knew; and in our own time of the remarkable achievements in several branches of science of Lord Rayleigh. I thank you once more most cordially, and express my high appreciation of this great and important centenary event. I am glad also to see so many distinguished foreigners who have come over to take part in this interesting gathering.

The Duke of Cambridge proposed "The Royal Institution of Great Britain," and in doing so remarked that the declared object of the Institution was the diffusion of knowledge and the

introduction of useful mechanical inventions, and the means were to be courses of philosophical lectures and experiments illustrating the applications of science to daily life.

The Chairman, in acknowledgment of the toast, said that it was a great honour that so many eminent representatives of foreign science had honoured with their presence the centenary of the Institution. It was just 100 years ago when the Institution entered upon its present premises. A long roll of names had lent lustre to their labours. Davy, Faraday, Young, Tyndall—above all, they should remember their founder, Benjamin Thomson, Count Rumford, whom it was easy to criticise, but whose virtues had been productive of great results. The work of the Institution had been in large measure the carrying out of Count Rumford's ideas. It was said that he intended an institution of a more practical or industrial character than the Institution now was. But changes had taken place. Facilities for communicating new discoveries were 100 years ago few; competition was less keen; there was then much dislike of innovation, and there was extreme jealousy with the working classes of any reduction of manual labour. It was thus necessary to popularise discoveries; and that was the aim of their founder. But now every such discovery was soon heralded to the public. Popular magazines had now articles on the manufacture of liquid air and other subjects of an abstruse character. Towards this wide diffusion of science the Royal Institution had largely contributed. Their principal objects were research, for which their laboratories gave ample means, and in respect of which special gratitude was due to Dr. Mond for his noble gift, and to Mr. Spottiswoode for his collection. The second object was to bring the results of research to the knowledge of those who could appreciate them, and these results were expounded in the evening lectures of the Institution. Thirdly, this knowledge was popularised by the afternoon lectures; and, finally, the rising generation were stimulated by the juvenile lectures to those who, it was hoped, were destined to take their part in future scientific investigation.

On Tuesday afternoon a commemoration lecture was delivered at the Institution by Lord Rayleigh, the Prince of Wales being present.

In the course of his remarks, Lord Rayleigh is reported by the *Times* to have said that though his was intended to be a commemorative lecture, the idea of commemorating all the work that had been done at the Royal Institution was hopeless. Remembering that on other occasions he had spoken of the achievements of Faraday and Tyndall, he thought on this occasion he would do well to go still further back in the century and speak of Dr. Thomas Young, one of the earliest professors of the Institution. Young occupied a very high place in the estimation of men of science—higher, indeed, now than at the time when he did his work. His "Lectures on Natural Philosophy," containing the substance of courses delivered in the Institution, was a very remarkable book, which was not known as widely as it ought to be. Its expositions in some branches were unexcelled even now, and it contained some things which, so far as he knew, were not to be found elsewhere. The earlier lectures dealt with mechanics, and the reader would find as sound an exposition of that science as could be imagined. Elastic resilience, or what we should now call potential energy, was better dealt with there than in any other treatise he knew, for Young discussed the subject with remarkable ingenuity, showing that the phenomena exhibited by two bodies coming into collision were comprehended under two cases. In the province of sound, Young was the originator of many of the most important principles on which the doctrine was now expounded, but it was with optics that his name was most closely associated, for Fresnel and he were the builders of the great structure of the undulatory theory. Lord Rayleigh then mentioned some of the points in which Young's good work had been overlooked. In Young's time one question of discussion was the change of the focus of the eye for varying distances. One suggested explanation, that accommodation was affected by an alteration in the external convexity of the eye, Young proved to be wrong by drowning his eye in water. This virtually altered the convexity, yet the power of accommodation remained, and he therefore concluded it was due to a muscular alteration in the internal lens of the eye. Young was singularly successful in the theory of cohesion and capillarity, in which some of his earliest work was done, and he was the first to deduce an estimate of molecular dimensions from data afforded by that theory. The size of the molecule, according to his calculations, was not very different from that admitted at the present day. In the theory of the tides he made great advances, while his views on heat were very interesting, since he had the utmost contempt for the idea prevalent in his time that it was a separate entity, and expressed the hope that in time philosophers might arrive at a true conception of its nature as motion. Speaking of work which had been done at the Institution by men who held no regular appointment in it, the lecturer noted that Wedgwood, in conjunction with Davy, was the first to produce anything that could be called a photograph, while instantaneous photography, such as was required for rapidly moving objects, was carried out for the first time by Fox Talbot in the laboratory of the Institution.

Another commemoration lecture is to be delivered as we go to press. Upon the invitation of the teachers of natural science in Oxford University, honorary members of the Institution will visit the University to-day.

The principal historical apparatus in the Institution has been on view during the centenary celebration. An interesting souvenir of the centenary is an illustrated brochure referring to William Spottiswoode, and to his collection of physical apparatus just presented to the Institution by his son, Mr. W. H. Spottiswoode. The souvenir includes a memoir of Spottiswoode, reprinted from NATURE of April 26, 1883; a list of lectures delivered by him at the Royal Institution, notes on some of the more important objects in the collection of apparatus, a reprint of a paper by Spottiswoode on the laboratories of the Institution, and a chronological list of original work developed at the Institution. A photogravure of Spottiswoode, and a number of brilliant half-tone pictures of sets of objects in the collection of apparatus, form part of Mr. Spottiswoode's interesting pamphlet.

## *THE HEIGHT OF THE AURORA.*[1]

A GOOD story used to be told some years ago of a candidate, who, when undergoing the torture of a *vivâ voce* examination, was unable to reply satisfactorily to any of the questions asked. "Come, sir," said the examiner, with the air of a man asking the simplest question, "explain to me the cause of the aurora borealis." "Sir," said the unhappy aspirant for physical honours, "I could have explained it perfectly yesterday, but nervousness has, I think, made me lose my memory." "This is very unfortunate," said the examiner, "you are the only man who could have explained this mystery, and you have forgotten it." One is not prepared to say that exact and complete knowledge of the cause of this curious phenomenon has greatly advanced since the time when the examiner made this crushing rejoinder, and it is therefore fortunate to have to treat of only one of the difficulties with which the whole problem is beset—the height at which the light manifests itself, or the limits of altitude above the earth's surface at which it may be seen. But a preliminary difficulty arises in connection with even this bare statement. Is the aurora borealis a localised phenomenon? Has it a habitation as well as a name? Or is it, like the rainbow, an optical exhibition resulting from the operation of certain physical causes. In the case of the rainbow, the causes admit of a tolerably simple explanation, and little is to be learnt from the study of its general features as seen in the sky; certainly we should not think it betokened any great show of wisdom to attempt to determine its height by any method of measurement or triangulation. The angular altitude is settled for us in a quite different manner, and it may

[1] "The Altitude of the Aurora above the Earth's Surface." By Prof. Cleveland Abbe. ("Terrestrial Magnetism," vol. iii., 1898.

be that we are displaying a crass ignorance in endeavouring to apply to auroræ methods of measurement which depend for their success upon an apparent displacement, due to a real change in the position of the observer. Students of trigonometry are taught at a very early stage the method of determining the distance of an inaccessible object, visible from two positions, and the elementary process employed, depending on the solution of a triangle, remains the favourite method of determining the height of the aurora. But just as our student knows that a successful solution of the problem demands that the angles must refer to a concrete object, so the observer of an aurora asks that this fitful light should have a definite "locus," that can be simultaneously seen and identified by two or more observers. Practically, this fundamental condition is not always easily satisfied, and other methods have in consequence been suggested which are founded on a supposed knowledge of the origin and behaviour of the auroral light. We may say at once that these methods, often ingenious in themselves, are so unsatisfactory in application that they can be passed over with a very brief mention.

There is no doubt but that the light out of which the auroral phenomena are formed emanates from a certain circumscribed region, but the real question is whether the arches and beams, the streamers and waves, the curtains and folds, with all the varied nomenclature that has been used to describe special features, are definite concrete objects. The fact that the aurora is accompanied with a special and presumably constant spectrum, possessing easily recognisable characteristics, does not help us at all to settle the question. That we have a source of light is admitted. The point at issue is, to what extent is it a subjective phenomenon, and how far does each observer see his own aurora as an optical illusion. Manifestly, those who accept the subjective theory have to encounter many objections. No one likes to admit that he is deceived in the character of a phenomenon so apparently real as that presented by a fine auroral display, though he will readily acknowledge that perspective must introduce some misleading features. Prof. Cleveland Abbe has, however, summed up the evidence with great care and completeness, and come to the conclusion that the idea of an individual existence must be definitely relinquished. He has been led to this conclusion from an examination of the various attempts that have been made to determine the height of the aurora; and whether we accept this decision or not, we shall at least be prepared to follow him in the assertion that the determination of the altitude of the aurora is a much more delicate problem, and perhaps also a more indefinite problem, than we have hitherto believed.

The evidence tending to this latter conclusion can be divided under many heads. We shall content ourselves with exhibiting two—one depending upon actual observation and measurement, the other resting upon theory and suggestion. The observers who have made the height of the aurora a special study can be grouped into two families—one represented by Richardson, Franklin, Hooker, and Silberman, who have actually seen the aurora below the clouds, or between themselves and neighbouring objects; and others like Loomis, Boscovich, and Twining, who place the height anywhere between 400 and 1000 miles. Between these advocates for a "ground" theory, and those who perceive a high aerial origin, we have a whole host of observers who are mainly led to their results by the selection and rejection of certain of their observations, if they are numerous, or have drawn their conclusions from single and accidental results. For the statement of claim of those who argue that the aurora is entirely confined to the lowest stratum of the earth's atmosphere, we must trust entirely to description. Measurement can evidently play no part, any more than it can on a bank of fog or a shower of hail. An admirable description, and one that would carry conviction to every impartial reader, if we could give it fully, has been written by Prof. J. P. Lesley, the distinguished geologist, of what he saw at Little Glace Bay, about seventeen miles from Sydney, Cape Breton: "It was my good fortune to observe an aurora, which to my eyes was embodied in and swept the earth with successive banks of Cape Breton fog. . . . In this fog bank hung, as it were, a brilliant curtain of light, with a wide fringe or flounce of maximum brilliancy, along the bottom edge, the light fading upwards along the curtain, but traceable to the very zenith, and the curtain stretching from the eastern horizon out at sea to the western horizon on the low hill-tops. The perspective was perfect. The curtain was evidently vertical, thin, straight, long enough to reach from one limit of the vision to the other, and floating broadside before the south wind towards the north. No reasoning could convince us (he had a companion) that these were not elements of the phenomenon, and, moreover, that the lower edge of the bright fringe was more than one or two hundred yards away at its nearest point when we first saw it. Its rate of departure from us was evidently that of the fog bank, or that of the gentle south wind then blowing. The perspective of the whole curtain changed in conformity with that supposition. We had both spent our lives in topographical work, and no record of triangulation made upon this aurora would alter my conviction of the posture and movements of the beautiful object, derived from the natural triangulations of the unassisted eye." Prof. Lesley further relates that he witnessed successive repetitions of the same beautiful appearance, but feebler in intensity, as though produced by the same causes gradually growing less and less active, from a process of exhaustion. Of the accuracy of his testimony he can entertain no doubt, and urges that it is unreasonable that the positive observations of those who have witnessed these displays should be despotically overriden by the trigonometrical calculations of other students. We are inclined to agree with him. It might, of course, be urged by those who consider that the upper and attenuated regions of the atmosphere are necessary for the production of auroral light, that such an exhibition was not a true aurora, and that if examined spectroscopically the light would not show the characteristic lines, nor would the magnetic instruments in the neighbourhood be agitated in the manner with which we have been made familiar when auroræ are present. On these points there seems to be no evidence, nor, so far as is known, have other physicists, who, like General Sabine, have "walked through an aurora as one would pass through a mist," verified their convictions.

But if the deductions of those who trust to the evidence of their senses can be set aside as affected by self-deception, others who rely on elaborate measurements are hardly in better case. With more pretentious methods, more rigorous criticism can be applied. Into the details of this criticism it is not convenient to enter here, involving as it does that much-debated quantity the "probable error," and still more recondite criteria for the rejection of discordant observations. But we have a right to expect an intelligible result, and this is not in every case forthcoming. If a man carefully surveyed a field with the view of determining its superficial area, brought out as his result a minus quantity, we should necessarily have a difficulty in explaining his deductions. And, without any exaggeration, it is precisely results of this character which are too frequently obtained from attempted measurements of auroræ. Of course, in the case of an object so ill-defined as an auroral arch, one expects to find large observational errors. But these

errors should have less effect in proportion as the conditions for securing accuracy in the solution of the problem increase. For instance, if we are going to measure a distance of two, four, or six hundred miles, a base of a mile or less in length will give us a very ill-conditioned triangle; but as we increase the length of the base, we should expect greater consistency in the results. Unfortunately this expectation is not realised. As an illustration, we select, out of the mass of measures that Prof. Cleveland Abbe has collected, three series of observations. The earliest of these sets was made in 1839, by MM. Bravais and Lottin in Norway, in latitude about $+70°$. The stations selected provided a base line about ten miles in length. Even at this moderate distance, the two expert observers could not recognise the same features in the auroral arch, or be certain that the angles measured with their theodolites referred to the same point. But Bravais, greatly daring, boldly applied trigonometrical methods, and deduced a parallax with mathematical rigour. Out of seven measures, as shown below, three parallaxes are negative and four positive, the total range being more than eleven degrees.

| | h. m. | Parallax ° ′ | | h. m. | Parallax ° ′ |
|---|---|---|---|---|---|
| 1839 January 12, | 5 37 | −3 42 | 1839 January 21, | 6 2 | −1 34 |
| ,, ,, 12, | 6 2 | +2 13 | ,, ,, 21, | 7 3 | +1 4 |
| ,, ,, 12, | 9 30 | +9 52 | ,, ,, 21, | 7 33 | +0 45 |
| ,, ,, 12, | 10 36 | −0 8 | | | |

Bravais concluded from all his observations that the mean altitude of the auroral arch is between 100 and 150 kilometres, but suggested that in order to determine "the parallax of the aurora more precisely than we have been able to do, it would be necessary to employ a longer base than ours, say about 100 kilometres in length, and directed as nearly as possible parallel to the vertical plane through the culmination of the arch." Fifty years later, Bravais' suggestion was carried out. Tromholt of Rostock, in Norway, occupied one of the stations near the scene of Bravais' earlier investigations, but extended the base line to a length of 66 miles. From one end of this base line, Tromholt made no less than 634 measurements, while 367 were made from the companion site. On comparing the results, however, only sixty corresponded as to time and referred, or were supposed to refer, to identical objects. These sixty were again reduced to forty-two, for reasons which do not appear; but it would be scarcely uncharitable to suggest that the remainder gave negative or impossible parallaxes. This modest remainder reminds one of Falstaff's "half-pennyworth of bread to his intolerable deal of sack." The final result, however, taken for what it is worth, assigns altitudes to the auroræ varying from 19 to 217 kilometres. Variations so great in amount cannot inspire confidence.

It might, however, be objected that in the Tromholt series, since the observers were separated some 100 km., that only the upper features of the aurora could be visible simultaneously from both stations, and that if the true or localised aurora was confined to the lower strata of the atmosphere, more or less illusory results might be expected. But we have a third series, made in about the same latitude, in which the observers were stationed only about a third of a mile apart, where they were in constant telephonic communication with each other, and where, therefore, the conditions were favourable to the removal of some of the difficulties that beset the parallactic method. Without quoting in detail the results obtained, it will be sufficient to say that, on discussion, the number of positive and negative parallaxes, even after judicious rejections, was found to be seventeen and twenty-three respectively, and that consequently no trustworthy value of the height could be deduced. Prof. Cleveland Abbe shows in this particular case how the calculus of probabilities has been forced in order to derive a plausible altitude from these observations. There is, however, no necessity to labour the point. We are simply concerned to show that the method tried under various conditions fails to give consistent results. Those who believe that the aurora is confined to the upper regions of the atmosphere reject the largest parallaxes, while those who are fighting for a low aurora will only accept the large values. The one fact which seems to stand out clearly after much patient examination is that the parallax does not increase with the increase of the length of the base line, or, in other words, it cannot be a true parallax. There is no dearth of reasons to explain these discrepant results. The inevitable error of observation arising from the feebleness of the light, the want of clear definition at the boundary of the arch, the possible movement of the object itself, and the want of absolute synchronism in the measurements at the stations, would be more than sufficient to make the method untrustworthy.

In presence of these difficulties, other methods depending on quite different principles have, as before intimated, been suggested and applied. The general principle involved is to derive the height from observations made at a single station, thus eliminating the second observer and the errors he introduces, putting in his place some more or less plausible suggestion as to the origin of the aurora itself. Galle, for instance, assumed that an auroral streamer is parallel to a free magnetical needle on the earth's surface, vertically below the beam. By observing the zenith distance of the auroral corona in his magnetic meridian, he obtained the angle made by his vertical with the parallel lines of light that compose the aurora, or the dip of the needle suspended in the region whence the light emanates. The magnetic charts show at what point on the earth's surface the needle would have the same dip. This gives a right-angled triangle whose base is known, and whose vertical side is the desired height. The weak point in the method is the assumption that the dip of the needle in the place where the corona is presumed to be coincides with that at the earth's surface immediately beneath it. Another method that has been applied is due to Bravais. It assumes that the auroral arch throughout its whole extent exists at a uniform distance above the earth's surface. If this assumption were justified, the determination of the azimuth and altitude of the two ends, and of the summit of the arch, would lead to a knowledge of its height. The method has been repeatedly tried with some modifications concerning the curvature of the arch, and of the position of the centre of the circle; but the very number of the variations that have been made condemns the accuracy and the applicability of the method. The observed apparent velocity of the motion of the arch, as seen from two stations in a magnetic meridian, has also been tried; and indeed, without further enumeration of the plans that have been suggested, one may say that the ingenuity and industry brought to bear upon this problem have been such, that if the definite beams and arches possessed a real existence and a definite locus, its solution would have been assured. That the parallax has remained so long indeterminate is probably due to the fact that the question has not been broached along appropriate lines. In his careful review, Prof. Cleveland Abbe makes some practical suggestions which, if applied, would go a great way to show how far optical illusion and perspective displacement affect this luminous phenomenon, which for so long has supplied poets with a simile for instability, and which under scientific examination gives additional point to the well-known lines of Burns:—

"Like the Borealis race
That flit ere you can point the place."

## THE TOTAL ECLIPSE OF THE SUN, MAY 1900.

WE have received the following circular from the U.S. Naval Observatory, Georgetown Heights, Washington, D.C., dated May 17.

In anticipation of the total eclipse of the sun May 28, 1900, the United States Navy Department has arranged with the Secretary of the Treasury to have admitted free of duty the instruments of foreign astronomers who may come to this country to observe the eclipse.

To this end astronomers abroad who contemplate an expedition to the United States are invited to notify the Superintendent of the Naval Observatory of the probable date of their arrival, with the name of the port at which they propose to disembark. The Navy Department will forward to the consuls of the different countries to which these observers belong, stationed at the ports in the United States at which the gentlemen shall arrive, a letter stating their purpose in travelling, which letter will be countersigned by the consul and presented to the collector at the port as a proof of their identity. Upon this the collector will extend all proper facilities for the speedy delivery of the instruments in question, free of duty and charges.

The Superintendent of the Observatory will be glad to hear from each of the proposed expeditions, in order that he may render such assistance as lies in his power. The path of totality extends through a thickly settled portion of the country, including some principal cities. Facilities for transportation are excellent, but it is recommended that instruments be securely packed and marked "delicate instruments—handle with care." The climate at that season is warm. The chances for clear weather are good.

Full information regarding routes of travel to proposed points, and other particulars, can best be obtained through consuls. Through the regular diplomatic channels notice should be conveyed to the local authorities of the city or town selected as a post of observation.

This Observatory will issue a pamphlet of instructions, containing large scale maps showing path of totality.

C. H. DAVIS,
Captain, U.S.N., Superintendent.

## NOTES.

THREE Fellows of the Royal Society have had honours conferred upon them on the occasion of her Majesty's eightieth birthday. Prof. J. S. Burdon Sanderson, Regius professor of medicine in the University of Oxford, has had the dignity of a baronetcy conferred upon him; and physiology is also honoured in the person of Prof. Michael Foster, joint-secretary of the Royal Society, and president-elect of the British Association, who has been appointed to be K.C.B. The promotions from C.B. to K.C.B. include Mr. W. H. Preece, who recently retired from his position as engineer-in-chief of the General Post Office.

AT the annual meeting of the Royal Society for the election of Fellows, the fifteen candidates nominated by the Council were elected into the Society. The names and qualifications of these candidates were given in NATURE of May 11 (p. 31).

THE five vacancies in the list of Foreign Members of the Royal Society have been filled by the election of the following: Prof. Ludwig Boltzmann, of the University of Vienna; Prof. Anton Dohrn, late Director of the Zoological Station, Naples; Prof. Emil Fischer, of the University of Berlin; Dr. Neumayer, of Hamburg; and Dr. Treub, Director of the Botanical Gardens, Buitenzorg.

THE Académie Royale des sciences de Turin announces that the Vallauri prize of 30,000 lire (£1200) will be awarded for the most important and celebrated work in the realm of physical science—using this term in a wide sense—published between January 1 of this year and December 31, 1902. The prize will be awarded without consideration of nationality, and no members of the Academy can participate in the competition. No account will be taken of works in manuscript. The president of the Academy is Prof. Guiseppe Carle, the secretary of the section of physical sciences is Prof. A. Naccari.

THE anniversary meeting of the Royal Geographical Society was held on Monday, and the medals awarded by the Council of the Society, as announced in our issue of May 11, were presented. The meeting was also made the occasion for the American Ambassador to present Sir John Murray with the gold medal awarded to him by the Geographical Society of New York. The medal contains the following inscription:—"Cullum Geographical Medal. Awarded to Sir John Murray, K.C.B., naturalist, deep sea explorer, oceanographer, editor of *Challenger* Reports, 1899."

IT is reported that the *Bakan* transport has left the Neva on her voyage to Spitsbergen. She has a crew of ninety men and eight officers, including Captain Ergomysheff, who is in command.

EFFORTS are being made in New York to form an American Physical Society similar to the Physical Society of London and the Deutsche physikalische Gesellschaft.

IT is announced in *Science* that Prof. F. L. O. Wadsworth has been appointed by the managers of the Western Pennsylvania University to succeed Prof. J. E. Keeler as director of the Allegheny Observatory. Dr. J. L. Wortman, of the American Museum of Natural History, has resigned his position in the museum in order to take charge of the new collections of vertebrate fossils in the Carnegie Museum at Pittsburg.

THE Rome correspondent of the *British Medical Journal* states that since the beginning of May, Prof. Koch and his assistants have installed themselves at the Municipal Hospital of Grosseto, where they are continuing their researches on malaria. Grosseto is a town situated in the line between Genoa and Rome, and is surrounded by an extensive plain, which in olden times was the Lacus Prelius of Cicero. This lake gradually became a morass and caused malaria. By skilful drainage and other means, the Italian Government has converted nearly the whole of this morass into valuable pasturage, and has thus lessened greatly the malaria. It is said that Prof. Koch intends to go to South Africa to continue his studies there when he leaves Grosseto.

A REUTER telegram from Stockholm, dated June 6, says that the Anthropological and Geographical Society in Stockholm has received the following telegram from Herr Vathne, a shipowner at Mandal:—"Captain Hueland, of the steamship *Vaagen*, who arrived there on Monday morning, reports tha when off Kola Fjord, Iceland, in 65° 34′ north lat., 21° 28′ west long., on May 14 he found a drifting buoy marked 'No. 7.' Inside the buoy was a capsule, marked 'Andrée's Polar Expedition,' containing a slip of paper, on which was written the following:—'Drifting buoy, No. 7. This buoy was thrown out from Andrée's balloon on July 11, 1897 10.55 p.m., Greenwich mean time, 82° north lat., 25° east long. We are at an altitude of 600 metres; all well. Andrée, Strindberg, Fraenckel.'" Herr Andrée made his ascent from Danes Island on July 11, 1897, at 3 o'clock in the afternoon, so that when the buoy was thrown out the explorer had only travelled seven hours and fifty-five minutes.

A CONFERENCE of representatives of Sea Fishery Boards with officials of the Board of Trade took place at Westminster on Tuesday, under the presidency of Mr. Ritchie. In his remarks

upon opening the proceedings, Mr. Ritchie referred to the forthcoming fishery conference at Stockholm, and said that whilst the Government were anxious to have the purely scientific branch of the subject dealt with, they had also instructed their delegates to see whether some agreement could not be come to whereby there should be an increase of the productiveness of the fisheries, and thus secure a permanent increase of fish in the markets adjoining the North Sea. Sir John Murray, Mr. Arter, and Prof. D'Arcy Thompson will represent the Government at the conference.

THE following State legislation in 1898, mentioned in the *American Naturalist*, is of interest to naturalists. New Jersey has provided for a State entomologist; Louisiana has passed a Bill providing for the establishment of a biological station in the Gulf of Mexico, to co-operate with the United States Fish Commission for the investigation of problems affecting the fisheries of the State; New York has forbidden the killing at any time of wild moose, elk, caribou, and antelope; Ohio has repealed the law relative to the trapping or killing of musk-rats, mink, and otter.

Model of the Moon. Field Columbian Museum. (Diameter, 19 feet.)

SIR CHARLES TODD has communicated some interesting notes to the Adelaide *Advertiser* of April 18, relating to the meteorology of South Australia during the past summer (November to March). November was one of the coolest on record, being 2°·8 below the average; this was followed by a hot December, with a mean temperature of 76°·4, which has only once been exceeded. January was the coldest during the forty-two years' records at Adelaide, and was followed by a hot February. The highest temperature during the month was 113°·6, which was the hottest day since January 1880. During the summer the thermometer read over 90° on forty-two days, of which about half were over 100°. The mean temperature for the five months, 71°·6, is just above the average.

AN apparatus, by means of which a record is automatically taken of the extent to which the steering wheel of a ship is moved and the helm put over, has been devised by Mr. J. E. Liardet. The apparatus consists principally of a couple of drums on which a "tape" or long strip of paper is wound. The movement of the wheel actuates these drums, unwinding the tape from one and winding it on the other, the motions being obtained by suitable toothed gearing. In the same way, a pencil fixed to a holder is caused to move to one side of the central line of the paper if the helm is put to port, and the other side when the helm is starboarded, the amplitude of the movement of the pencil being proportionate to the angle of helm. In this way, an accurate record may be kept of the number of times and the amount the helm is shifted. It is proposed to add clockwork mechanism, so that the paper will be continuously unwound at a uniform speed, and the time at which any movement is made will thus be recorded.

ONE of the most interesting additions to the Field Columbian Museum in 1898 was the Schmidt-Dickert relief model of the moon, an illustration of which we are enabled to give by the courtesy of Mr. F. J. V. Skiff, the director of the museum. The model is in the form of a hemisphere having a diameter of 19 feet, and it exhibits very accurately the surface features of the moon. It was prepared with great care from the charts of Beer and Madler, and of Dr. Schmidt, of the Athens Observatory. Five years were occupied in its construction. The sections of the model have been for several years in Chicago, but they have only been available to the public at rare intervals. It is through the generosity of Mr. L. W. Reese that this noteworthy object has been added to the collections in the Field Columbian Museum. The model as exhibited will undoubtedly prove of great interest to the public generally, and especially to students of astronomy. Chicago is fortunate in possessing such a striking representation of lunar topography.

THE absence of palæolithic implements from Scotland has been explained by glacial conditions or the submergence of the country. Neither of these explanations seems to the Rev. F. Smith to be adequate, for during part at least of the period in question (as during the deposition of the *Cyrena fluminalis* beds) the climate of Britain was warmer than it is now, and the geographical occurrence of palæolithic remains in England and France evidence the period to have been that of great upheaval, and it is improbable that Scotland was then submerged. He finds (*Proc. Philosoph. Soc.*, Glasgow, 1899) a more sufficient explanation in the suggestion that the searchers were looking for the wrong thing. The ordinary types being flints, flint specimens were sought in Scotland; but no flint exists *in situ* in Scotland. Either palæolithic man was limited in his habitat to the geographical occurrence of flint, or that such specimens as might exist in Scotland would be fashioned of the rocks native to the country, and would be lacking in the peculiar characteristics of flaked flint. The first assumption is probably erroneous, so Mr. Smith has spent many years to an investigation of the alternative proposition. Under analogous conditions to those which obtain in the Somme Valley, he has found in the valleys of the Forth, Tay, Earn, Allan, Dee and Don, and in the Clyde Estuary, stones of quartzite, basalt, and various igneous rocks which certainly bear a superficial resemblance to well-known palæolithic types. The author acknowledges that these stones can only be fully appreciated by being handled, and that his illustrations do not do them justice. The author's contention is certainly tenable, but the evidence of the specimens can only be gauged by actual inspection.

THE origin of religion has long been a difficult problem, and is likely to remain obscure for some time yet. The germ, according to Tylor, lies in the belief in spiritual beings; Lippert finds it in the worship of the soul. Herbert Spencer has stated that ancestor worship is the root of every religion, and again that there is strong warrant for the inference that ghost-propitiation is the origin of all religions. C. L. Henning attempts in *The American Anthropologist* (vol. xi. p. 373) to solve the question from quite another standpoint. All the investigators in this field, without exception, have neglected one principal factor in their respective researches—the economic conditions. Primitive man had no religion; this was the product of much later times, and did not arise from a so-called "religious sentiment." A system of social virtues, or in other words a primitive social morality, was early developed owing to men being united in hordes; but this has nothing to do with religious perceptions. A man who during his life ameliorated the economic conditions of his tribal companions was not forgotten after his death; of this there are innumerable past and present examples. Such men after their death became heroes or benefactors of their respective tribes. The veneration they enjoyed during life changed after their death into ancestor worship, and later on into soul worship; the two latter forms of worship are the beginning of the historical evolution of religion.

THE Geology and Agriculture of the Department of the Lozère, in the south of France, forms the subject of an elaborate article by M. Ernest Cord (*Bull. de la Soc. d'Encouragement pour l'Industrie Nationale*, Paris). In the second part of his work, published in April, the author gives an account of the Triassic and Liassic strata. The Trias, which consists mostly of sandstones and conglomerates, with some argillaceous layers, occupies small tracts of woodland with fine chesnut-trees and much oak coppice. The central plateau of the Lozère, consisting of gneiss, mica schist, and granite, is bordered by Jurassic rocks which formerly overspread this group of ancient rocks. From the Rhætic Beds to the Upper Lias the various stages are well represented. Much of the soil on the Rhætic formation is a kind of arkose, derived from granitic débris in the strata, and it is dry and sandy; nevertheless there are calcareous ingredients, and the beech flourishes. The higher portions of the "Infra-Lias" and the Lias proper consist mainly of limestones, marls and clays, and they form a rich agricultural district—cereals, vegetables and fruit being cultivated. Attention is directed to the magnesian limestones, which form striking features in the upper part of the "Infra-Lias." These limestones are much fissured, and the streams in many instances pass underground and reappear at lower levels. Several illustrations of these swallet-holes are given. The magnesian waters have an injurious effect on those who are accustomed to drink them, and it is noted that goitre is met with among the residents in these districts.

IN the *Verhandlungen der k. k. geol. Reichsanstalt*, No. 2, 1899, some results of recent geological work in southern Dalmatia are described by G. Bukowski. In the region examined, the tectonic relations were found to be of a very complex character, and overfolding and overthrusting have occurred upon an enormous scale. This may be well understood when it is said that the Hallstadt limestones, forming the base of the series observed, are overlain by Cretaceous and older Tertiary rocks, to be followed in turn by Triassic Dachstein-limestone. In places, the Tertiary beds have become completely squeezed out, in which case the Dachsteinkalk rests directly upon the Cretaceous limestones. In the region of southern Pastrovicchio, the upper beds of the *Diplopora*-limestone have yielded a brachiopod-fauna peculiar for its richness in species and individuals of *Spirigera*. In the upper Triassic limestones, a marked change of facies is apparent. The tufaceous complex of the Dzurmani-beds is overlain by rocks having a Hallstadt cephalopod-facies, which yields in turn, in the higher beds, to a coral-reef facies.

To the *Verhandlungen der k. k. geol. Reichsanstalt*, No. 3, 1899, Dr. J. J. Jahn contributes a short paper on the occurrence of moldavite (bouteillenstein) in the pyrope-bearing sands (early Diluvial) of northern Bohemia. After describing specimens found at localities west of Trebnitz, the author gives a summary of the results of experiments carried out by Herr Jos. Bareš, who has investigated the behaviour of moldavite when subjected to very high temperatures, with a view to clearing up the question of its origin. From a comparison of the chemical composition and physical properties of serpentine and moldavite, the hypothesis that the latter has had its origin in the former, as held by Helmhacker, derives no support whatever. By experiments carried out with various kinds of glass, and a comparison of the behaviour of these and of moldavite at temperatures ranging up to 1400° C., as also by a comparison of the chemical composition of the respective substances, Bareš obtains strong evidence against the correctness of the theory that bouteillenstein is an artificial product of glass manufacture. Further experiments refute also the hypothesis that moldavite may have been produced, by the aid of volcanic activity, from felspar-bearing rock rich in silica. From a consideration of the form and surface structure of the various specimens, and their behaviour under the highest temperatures, Herr Bareš agrees with Dr. F. E. Suess in recognising the probability of a cosmic origin.

THE May number of the *Zoologist* contains a very interesting account by Mr. Cronwright Schreiner on the recent extraordinary "trek" of Springbuck in the Cape Colony. The vast number in which these antelopes migrated in former years is a familiar fact; but in recent times they were believed to have ceased for ever. All the more remarkable, therefore, is it to hear of the great "trek" which occurred in July 1896. On the occasion when he saw the largest herd, Mr. Schreiner believes that there

were at least half a million antelopes in sight at once; and from this it is inferred that the whole "trek" must have included millions. Of course, thousands of head fell to the rifles of the Boer and other hunters; and a brisk trade sprang up in hides and meat. The writer of the paper infers that a migration on such a scale will never be seen again, for the reason that the Springbuck will be unable to recruit their numbers to a sufficient degree.

WE are asked to announce that the second annual dinner of the Association of Old Students of the Central Technical College will be held on Thursday, July 6.

THE *Quarterly Journal of Microscopical Science* contains two papers by Mr. J. E. S. Moore, dealing with his researches on the Molluscs of the great African lakes, especially Tanganyika. In the first paper, which discusses the morphology of the two littoral forms *Tanganyikia* and *Spekia*, the most interesting relates to the ancestry of the terrestrial *Cyclophoridae*. It is suggested that they trace their origin from some fresh-water derivative of the Tanganyika genus *Purpurina*, such as the cretaceous *Pyrgulifera*, which may represent a fresh-water non-halolimnic development of the type. The second paper deals with the truly halolimnic genera *Nassopsis* and *Bythoceras*. In regard to these and allied types, the author makes the following concluding observations. "We have the wonderful similarity of the halolimnic shells now living in Tanganyika to those which have been left fossilised at the bottom of the old Jurassic seas; and, lastly, there are the morphological characters of the halolimnic animals themselves, whereby they become mentally depicted like nothing so much as the incompletely developed embryos of numerous living oceanic types."

A COPY of volume x. of the *Transactions* of the American Pediatric Society, edited by Dr. Floyd M. Crandall, has been received. A number of papers and reports on infantile diseases are contained in the volume, one of the most important being a statement of the results of the Society's collective investigation on infantile scurvy in North America.

"A Select Bibliography of Chemistry" (1492–1892), by Prof. H. Carrington Bolton, was published in 1893. The first supplement of this volume, including words omitted in the previous volume, and bringing the literature of chemistry down to the close of the year 1897, has just been issued as No. 1170 of the Smithsonian Miscellaneous Collections. The sections into which the titles are grouped are: bibliography, dictionaries, history, biography, chemistry (pure and applied), and periodicals, the titles being in each case arranged alphabetically according to authors. The section dealing with alchemy has been dropped. The number of titles in the original volume was 12,031, and the number in the present volume is 5554, making a total of 17,585. Germany comes first in the number of additional titles, with a total of 1461. France follows with 1085 titles, England with 972, and Russia with 581 titles. The next six countries in order of their number of contributions to chemical literature are: Iceland, 434; Sweden, 196; Holland, 191; Denmark, 151; Portugal, 123; Bohemia, 98.

A COMMENDABLE characteristic of the report of the Marlborough College Natural History Society is a collection of anthropometrical particulars referring to boys in the school, obtained by Mr. E. Meyrick. The measurements are a continuation of records published last year. For each boy the information tabulated is his form, age, height, weight, size of chest expanded and contracted, and where possible the increase compared with last year's measures. Information of this kind is of real service to students of physical anthropology. Among other noteworthy matters in the report is a list of 417 wild flowering plants observed by members of the botanical section, one member, Mr. F. E. Thompson, having obtained no less than 189, a worthy conclusion on his part to a series of botanical observations extending over thirty years. Appended to the usual meteorological statistics for every day of 1898 is a summary of the meteorology of Marlborough for the ten years 1889–1898. In addition, the report contains sectional reports, notes and observations, notes on lectures, and a variety of other information—all instructive and of interest as showing the development of the scientific spirit in a public school.

THE additions to the Zoological Society's Gardens during the past week include a Green Monkey (*Cercopithecus callitrichus*, ♀) from West Africa, presented by Dr. H. Strachan; a Rufous Tinamou (*Rhynchotus rufescens*) from Brazil, presented by Mr. Henry Bell; a Common Kingfisher (*Alcedo ispida*) from Ireland, presented by Mr. Ronald Edwards; two Jackdaws (*Corvus monedula*, white var.), European, presented by Mr. Eardley Wilmot B. Holt; two Secretary Vultures (*Serpentarius reptilivorus*) from South Africa, presented by Mr. J. E. Matcham; two Green Turtles (*Chelone mydas*) from the Gulf of Manor, presented by Captain Geo. G. C. Stevenson; two Black-striped Wallabies (*Macropus dorsalis*, ♂ ♀) from New South Wales, two Stonechats (*Pratincola rubicola*) from South of France, two Derbian Parrakeets (*Palaeornis derbyana*) from China (?), a South Albemarle Tortoise (*Testudo vicina*) from South Albemarle Island, deposited; a Musk Duck (*Biziura lobata*) from Australia, three Barbary Turtle Doves (*Turtur risorius*) from Africa, a Tuatera Lizard (*Sphenodon punctatus*) from New Zealand, purchased; two Collared Fruit Bats (*Cynonycteris collaris*), born in the Gardens.

## *OUR ASTRONOMICAL COLUMN.*

COMET 1899 *a* (SWIFT).—

*Ephemeris for 12h. Berlin Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ | Br. |
|---|---|---|---|
| June 8 | 15 59 12 | + 46 18·1 | 0·88 |
| 9 | 48 32 | 44 39·5 | |
| 10 | 39 2 | 43 2·2 | 0·75 |
| 11 | 30 32 | 41 27·2 | |
| 12 | 22 56 | 39 54·7 | 0·63 |
| 13 | 16 5 | 38 25 4 | |
| 14 | 9 57 | 36 59·3 | 0·53 |
| 15 | 15 4 27 | 35 30·6 | |
| 16 | 14 59 29 | 34 17·3 | 0·45 |
| 17 | 54 57 | 33 1·3 | |
| 18 | 50 51 | 31 48·7 | 0·38 |
| 19 | 47 7 | 30 39·7 | |
| 20 | 14 43 45 | + 29 33·4 | 0·32 |

Being now almost two months past perihelion, the comet is rapidly becoming less conspicuous. During the week it will pass from Herculis into Bootis, its path being nearly parallel to a string of 4th mag. stars $\phi$ and $\chi$ Herculis, $\mu$, $\delta$ and $\epsilon$ Bootis.

## *THE ROYAL OBSERVATORY, GREENWICH.*

ON Saturday last (June 3), the Astronomer Royal presented his Annual Report to the Board of Visitors of the Royal Observatory, Greenwich. The weather was all that could be desired, and the large number of guests, numbering among them Prof. Cornu, was able to comfortably inspect the buildings and instruments, which had as usual been thrown open to view.

The following is a brief *résumé* taken from the report:—

*Buildings.*

The new Observatory building, which has been in progress since 1891, was completed last March, by the addition of the east and west wings. This handsome building provides much needed accommodation for the Observatory staff, for the photo-

graphic records and books of calculations, and for the library, which had long outgrown the rooms hitherto available for it. In the new Observatory building—which is cruciform in shape, having four wings of three stories, with a central tower carrying the Thompson equatorial and dome—the staff occupies the principal floor, the library will be placed in the ground floor of the north, east and west wings, the ground floor of the south wing being fitted up as a workshop, and the upper floor will accommodate the photographic and other records and the stock of publications of the Observatory.

The completion of the new Observatory building, which at three points breaks into the existing boundary fence, makes it desirable that the boundary of the Observatory should be enlarged in order to show off the handsome new building, and a proposal to give effect to this is under the consideration of the Admiralty.

The new Magnetic Pavilion, in an enclosure in Greenwich Park, at a distance of about 350 yards from the Observatory, on the east side, was completed at the end of last September, and the magnetic instruments for absolute determinations have been installed there. The greatest care has been taken to exclude all iron in building the Magnetic Pavilion, and the site has been selected so that there is no suspicion of magnetic disturbance from iron in the neighbourhood. The enclosure also provides a good meteorological station, where the standard thermometers and rain-gauges have been mounted.

*Transit Circle.*

The sun, moon, planets, and fundamental stars have been regularly observed on the meridian as in previous years. The number of observations made from 1898 May 11 to 1899 May 10, was as follows :—

| | |
|---|---|
| Transits, the separate limbs being counted as one observation ... ... ... ... | 11,764 |
| Determinations of collimation error ... ... | 298 |
| Determinations of level error ... ... ... | 694 |
| Circle observations ... ... ... ... | 10,830 |
| Determinations of nadir point (included in the number of circle observations) ... ... | 665 |
| Reflection observations of stars (similarly included) ... ... ... ... ... | 560 |

The number of stars observed in 1898 was about 5000.

The number of meridian observations in the first three months of 1899 was unusually large, being 1200 more than the average of the three preceding years. The excess was entirely in January and February, for which months the number of observations was double the average number. This unusually large number of observations has caused great pressure on the computing staff in that branch, and it is much to their credit that the reductions have fallen so little behind.

The apparent correction for discordance between the nadir observations and stars obtained by reflection for 1898 was found to be $-0''{\cdot}36$. The results of recent years are as follows :—

| | Mean | Range |
|---|---|---|
| 1880–1885 | $-0''{\cdot}34$ | from $-0''{\cdot}29$ to $-0''{\cdot}45$ |
| 1886–1891 | $+0{\cdot}03$ | from $-0{\cdot}12$ to $+0{\cdot}09$ |
| 1892–1898 | $-0{\cdot}30$ | from $-0{\cdot}25$ to $-0{\cdot}36$ |

New steel screws for the microscope micrometers were introduced in 1886, and in October 1891 the object-glass was repolished, and a new steel telescope micrometer screw was introduced.

Both microscope and telescope micrometer screws have been examined, but show no errors which would account for this discordance.

The co-latitude of the transit-circle, as found from observations of about 600 stars in 1898, is $38^\circ\ 31'\ 21''{\cdot}75$, differing by $-0''{\cdot}15$ from the adopted value. The effect of Chandler's latitude variation was computed for each of these stars within the limits $10^\circ$ and $35^\circ$ N.P.D. The table, which is given in the Report, exhibiting the effect of Chandler's correction to the colatitude on the means of groups arranged for each hour of right ascension, shows how entirely its influence is eliminated from the resulting co-latitude.

The mean error of the moon's tabular place (computed from Hansen's lunar tables with Newcomb's corrections) is $-0{\cdot}143$s. in R.A. and $+0''{\cdot}14$ in N.P.D. deduced from 104 observations. These are equivalent to an error of $-2''{\cdot}23$ in longitude and $+0''{\cdot}21$ in ecliptic north polar distance.

In the last Report, the equivalent error in longitude was $-1''{\cdot}97$ and $+0''{\cdot}16$ in ecliptic north polar distance.

From June to December 1898 a new determination of the division errors of the transit-circle was made by Mr. Dyson and Mr. Thackeray. An account of this investigation has been published in the *Memoirs* of the R.A.S., vol. liii., so that we need not refer again to it here.

*The New Altazimuth.*

After the date of the last Report, it was found that the readings of the several microscopes varied systematically with the direction in which the instrument was swung. As this pointed to a constraint in the axis, several modifications were made in different parts of the instrument. These various changes were not completed till February 23, and since then the observations, both of transits and zenith distances in reversed positions, show a satisfactory accordance.

Among the observations made with this instrument may be mentioned 1017 R.A. observations of the sun, planets and stars, 961 N.P.D. observations of the same bodies, and 20 observations in R.A. and N.P.D. of the moon.

*Thompson Equatorial.*

The return of the object-glass of the 26-inch refractor on 1898 May 16 is referred to in the last Report. Slight figuring of the outer surface under Sir Howard Grubb's direction was continued till June 8. The object-glass was further tested by photographs taken inside and outside of focus and with diaphragms, and was finally approved in September. The new 30-inch mirror, of slightly shorter focal length (corresponding to the length of the tube), was received from Dr. Common on September 1. Photographs to test the mirror were taken in the principal focus and also in the secondary focus, and it was found to be quite satisfactory.

With the 26-inch refractor, twelve successful photographs of Neptune and its satellite have been obtained, using the occulting shutter to screen the planet during the greater part of the long exposure necessary to show the satellite, a series of short intermittent exposures for the planet being given by lifting the arm of the shutter. The results of these observations are given in the *Monthly Notices of the Royal Astronomical Society*, vol. lix., May. Forty-two successful photographs of sixteen double stars have also been obtained, including six of Aldebaran, for which the occulting shutter was used in order to obtain measurable images of Aldebaran and the faint companion, for which a 20m. exposure was required. A few photographs of fields of stars have also been obtained.

With the reflector, thirty-two photographs of the planet Eros were obtained between September 20 and March 31, nine photographs of Neptune and its satellite, four of Comet Brooks, and one of Comet Tuttle. To investigate the distortion of the field, five photographs of the Pleiades have been taken.

With an exposure of an hour, a "fine photograph of the Andromeda nebula has been obtained."

*28-inch Refractor.*

This instrument has been used throughout the year for micrometric measurements of double stars. Four hundred and ten stars have been measured; 206 of these have their components less than $1''{\cdot}0$ apart, and 87 less than $0''{\cdot}5$. The stars the distance apart of which is less than $1''{\cdot}0$ have been measured on the average on three nights each, and the wider pairs on two and a half nights. The wider pairs measured consist of stars in which there is a considerable difference of magnitude between the components, of third companions to close pairs, and of stars which are of special interest.

A long series of measures of 70 Ophiuchi has been obtained.

*Astrographic Equatorial.*

During the year ending 1899 May 10, 465 plates have been taken on 120 nights. Of these 78 have been rejected, viz. 34 because the exposure was interfered with by cloud, or because the images were too faint to show 9th magnitude stars with a 20s. exposure; 17 owing to faults in guiding or exposure; 8 on account of wrong setting; and 19 from miscellaneous defects.

The following statement shows the progress made with the photo-mapping of the heavens :—

| | For the Chart (Exposure 40m.). | For the Catalogue (Exposures 6m., 3m., and 20s.). |
|---|---|---|
| Number of photographs taken | 256 | 200 |
| ,, successful plates | 211 | 167 |
| ,, fields photographed successfully | 206 | 160 |
| Total number of successful fields reported 1898 May 10 | 828 | 909 |
| Number of photographs, previously considered successful, rejected during the year | 7 | 39 |
| Total number of successful fields obtained to 1899 May 10 | 1027 | 1030 |
| Number still to be taken | 122 | 119 |

Of the 122 fields to be photographed, 101 are within 7° of the pole. The photography of this part of the sky was purposely deferred till near the epoch 1900, and has just been begun.

In last year's Report, we mentioned that 166 catalogue plates out of 909—that is, nearly one-fifth of the total number—and 90 chart-plates out of 828, had deteriorated owing, probably, to the effect of damp in the building in which they have to be stored pending the completion of the new physical laboratory.

This year we read that the deterioration of some of the plates has continued, as it was not found practicable to move the photographs into the new Observatory building till March. Besides the plates which have been rejected during the year, as mentioned in the tabular statement above, there are about forty catalogue plates in the zones yet to be measured which should be taken again. The damaged chart-plates have all been copied, and the positives on glass will in any case be available. But it seems advisable that all the damaged plates, whether measured or copied, should be replaced by others, and, as the photo-mapping for the zone allotted to Greenwich is now nearly completed, this work can shortly be taken in hand.

*Heliographic Observations.*

In the year ending 1899 May 10, photographs of the sun have been taken on 195 days, either with the Dallmeyer or Thompson photo-heliographs. The former, mounted on the terrace roof of the south wing of the physical observatory, was used as the regular instrument for solar photography up to and including 1898 July 27, when the Thompson 9-inch photo-heliograph was substituted for it. The Dallmeyer photo-heliograph was dismounted and placed in the upper floor of the museum on 1898 October 13. Of the photographs taken with either instrument, 394 have been selected for preservation, besides sixteen photographs with double images of the sun, for determination of zero of position-angle. Photographs to supplement the Greenwich series have been received from India and Mauritius up to 1899 January 13.

For the year 1898, Greenwich photographs have been selected for measurement on 165 days, and photographs from India and Mauritius (filling up the gaps in the series) on 192 days, making a total of 357 days out of 365 on which photographs are at present available. No photographs have been received from Mauritius of later date than 1898 August 7, and as the eight days which are at present unrepresented are all since that date, it is possible that the record for the year may yet be rendered complete.

The chief incident in the history of the sun's surface, during the period covered by this Report, was the very remarkable temporary revival of activity which set in at the end of July and lasted almost to the middle of November, culminating in the appearance of the great group of September 3–15. Apart from this, the sun's surface has been very quiet during the year, the spots being few, isolated, and small. There have, however, been no such long-continued instances of the entire absence of spots as to suggest that the minimum had been actually reached or is immediately at hand, the number of days without spots for which a record is at present available being 49, as compared with 42 in the previous Report.

*Magnetic Observations.*

The variations of magnetic declination, horizontal force, and vertical force, and of earth currents, have been registered photographically, and accompanying eye observations of absolute declination, horizontal force, and dip have been made as in former years.

On the completion of the new Magnetic Pavilion, last September, the Gibson deflection instrument and the Airy dip-circle were mounted there, and regular determinations of magnetic horizontal force and dip have been made there from that time.

The principal results for the magnetic elements for 1898 are as follows:—

| | | |
|---|---|---|
| Mean declination | | 16° 39'·2 West. |
| Mean horizontal force | | 3·9878 (in British units). 1·8387 (in Metric units). |
| Mean dip | January to June | 67° 12'·4 (with 3-inch needles). |
| | October to December | 67° 11'·3 (with 3-inch needles). |

These results depend on observations on the site of the Magnetic Pavilion, and are free from any disturbing effect of iron. The correction to the declination, as found in the Magnet House, is −10'·7, deduced from the observations with the Elliott declinometer, in September and October, and with the new declinometer in the Magnetic Pavilion, the values found with the two instruments being precisely the same.

The question of the protection of the Observatory from disturbance of the magnetic registers by electric railways or tramways in the neighbourhood has caused much anxiety during the past year. A number of such railways are now projected, and the value of the magnetic registers, which have now been carried on continuously for nearly sixty years, will depend entirely on the conditions under which electric traction is used. Steps have been taken, in concert with Prof. Rücker, acting on behalf of Kew Observatory, to have a special clause inserted for the protection of Greenwich and Kew Observatories. This has already been accepted in several cases, and it is hoped that it will be agreed to in others where necessary.

*Meteorological Observations.*

The mean temperature of the year 1898 was 51°·3, being 1°·8 above the average for the fifty years 1841–1890. During the twelve months ending 1899 April 30, the highest daily temperature in the shade recorded in the open stand was 92°·1 on September 8. The highest reading recorded in the Stevenson screen was 90°·0 on the same day.

The monthly mean temperatures were in excess of their corresponding averages from August to February (inclusive) to the mean amount of 3°·9. In December, the excess amounted to 6°·1, and in September to 4°·9. In the five remaining months of the year the mean temperatures were below the average values.

The mean daily horizontal movement of the air in the twelve months ending 1899 April 30 was 291 miles, which is ten miles above the average for the preceding thirty-one years. The greatest recorded movement was 950 miles on January 21, and the least 67 miles on March 14. The greatest recorded pressure of the wind was 33 lbs. on the square foot on February 13, and the greatest hourly velocity 53 miles on January 12.

The number of hours of bright sunshine recorded during the twelve months ending 1899 April 30 by the Campbell-Stokes instrument was 1500 out of the 4454 hours during which the sun was above the horizon, so that the mean proportion of sunshine for the year was 0·337, constant sunshine being represented by 1.

The rainfall for the year ending 1899 April 30 was 22·74 inches, being 1·80 inches less than the average of fifty years. The number of rainy days was 158. The rainfall in the month of September amounted to 0·305 inch, being the smallest September rainfall on record in the period 1841–98, with the exception of September 1865, when the rainfall was only 0·16 inch.

*Longitude of Killorglin.*

The longitude of Killorglin, at the head of Dingle Bay, Ireland, was determined in October and November. The station was selected in order to eliminate, as far as possible, the effect of local attraction at Valentia and Waterville, both of which longitude stations are situated between the Atlantic on the west and a mountain mass on the east.

A desire has been expressed by the International Geodetic Association for a re-determination of the longitude of Paris—Greenwich in view of the discordance in the results found by the French and English observers respectively in the two de-

terminations in 1888 and 1893, and the Council of the Paris Observatory have recommended that this work should be undertaken in concert with Greenwich Observatory. As a preliminary to the actual longitude operations, it seems essential that the instruments to be used by both parties of observers should be thoroughly tested at contiguous stations.

## SPURIOUS EARTHQUAKES.

IN compiling the seismic record of any country, we are liable to errors from two sources. We cannot help omitting a large number of slight earthquakes, which it is difficult to separate from the countless tremors that are artificially produced. On the other hand, we include a smaller, but still important, number of shocks which are not seismic in their origin, though they simulate earthquakes in many ways. Errors of the former class are, of course, difficult to prevent, though they tend to become less frequent when attention is given to the subject. Those of the latter class may sometimes be eliminated by a study of the different kinds of disturbance which have been, or might be, mistaken for true earthquakes.

The majority of spurious earthquakes in this country are produced by the firing of heavy guns, the bursting of meteorites, and the fall of rocks in underground channels. Explosions and landslips produce disturbances which are at first frequently mistaken for earthquakes, but their real origin cannot fail to be soon discovered and remembered. Perceptible tremors are also produced in buildings by thunder, but it is improbable that permanent errors can thus arise, for the long duration of the sound, in conjunction with the small area affected, provides a simple test. I shall, therefore, confine myself to the first three causes mentioned in this paper.

### FIRING OF HEAVY GUNS.

The sound and tremor produced by the firing of heavy guns are sometimes perceived at great distances; but, as I propose to deal with this subject in another paper, I will merely mention here that observations of the sound at distances exceeding one hundred miles are by no means uncommon.

On two or three occasions within the last few years I have been able to trace supposed earthquakes to this source. On the first (January 7, 1890), two shocks were felt in the southwest of Essex at 12.30 and 1.25 p.m. All the places from which I received accounts lie close to a line running north-east from Woolwich, with one exception, in which the direction is north by east. I have no report of the direction of the wind in the immediate neighbourhood, but southerly and southwesterly breezes were generally prevalent over the whole country on that day. Near the boundary of the district affected, the disturbance was supposed to be seismic by observers who felt the Essex earthquake of 1884: somewhat nearer the origin, the sound resembled the report of a heavy gun; while, six miles from Woolwich, the noise and shock were referred without hesitation to their true cause, the discharge of a 110-ton gun at Woolwich at the times mentioned.[1]

On May 5-6, 1893, a number of shocks were felt at nearly regular intervals in the Isle of Man. At Douglas, where they were very slight, they were regarded as earthquakes; further south, at and near Castletown, they were described as resembling the reports of heavy guns, but the likeness was not striking enough to raise doubts as to their seismic character when it was once asserted; at the Chickens Lighthouse, off the extreme southern point, the keeper informed me that no earthquakes were felt, but that there must have been some man-of-war practising to the south-south-west; and this, on inquiry at the Admiralty, was found to have been the case, H.M.S. *Neptune*, a first-class battle-ship, having been engaged in heavy-gun practice to the south of the island during the very times when the reported earthquakes were heard and felt.

*Tests.*—The principal tests by which the true character of these disturbances may be distinguished are the following: (1) When several are noticed on one day, they are of not very unequal intensity, and may occur at nearly regular intervals. (2) The disturbance is apparently communicated through the air. (3) The gradually increasing confidence in one direction with which the shocks are attributed to gun-firing is no doubt the most important test. (4) In many cases, the position of the disturbed area or the time of occurrence may lead to suspicions regarding the seismic nature of the shocks. (5) If the disturbed area were extensive, a few good time-observations would give a velocity approximating to that of sound-waves in air.

[1] The supposed earthquake at Chelmsford on January 7 (NATURE, vol. xli., 1890, p. 369).

### THE BURSTING OF METEORITES.

The explosive bursting of meteorites is one of the commonest causes of spurious earthquakes. The mistake in such cases, it is probable, arises not so much from any close similarity between the two phenomena, as from the exclusion in the minds of the reporters of all artificial causes, and the consequent inference of a seismic origin. The explosion of a large meteor, weighing one or several tons, on entering the atmosphere is heard, according to the late Prof. H. A. Newton, for "a hundred miles around, shaking the air and the houses over the whole region like an earthquake." (NATURE, vol. xxxiv., 1886, p. 533). Many such cases might be quoted, and a very large number must be known to those who have made a special study of the subject, but the following are probably sufficient for the present purpose.

*West of England Meteorite*, January 25, 1894.—At an early stage of its flight, this meteor, according to Mr. Denning, passed over Chester at a height of fifty-eight miles. It travelled in a direction from N.N.W. to S.S.E., passing almost over Droitwich and Worcester, at a height of about twenty-three miles, and disappearing with an explosion when about sixteen miles above a point four miles north of Ashchurch (near Tewkesbury). Two minutes after its disappearance three detonations were heard at Worcester, "the last being of exceptional violence, shaking buildings and causing the earth to vibrate." At Brinscombe (near Stroud), about a minute or a minute and a half after its disappearance, "there came (apparently from the north-east) a series of explosions, which sounded . . . like a number of field-pieces fired in rapid succession, followed by a volley of musketry." One of the most interesting observations from the present point of view is that made by an observer at Parkfields (near Ross). "A slight earthquake," he says, "was felt here. . . . I heard a loud rumbling noise like an explosion, lasting two or three seconds, which I took for thunder. A young lady who had just gone up to her room tells me that there were two slight shocks, the motion being similar to that of a steamer at sea. . . . I am informed that it was accompanied by a lurid light, which lasted some time, and that objects at a considerable distance were plainly visible. The night was dark and cloudy, with some rain." The recorded observations are too few in number to determine the boundaries of the sound-area and disturbed area, but a perceptible tremor was felt at Alvechurch (near Redditch), which is thirty-nine miles from Ross, and the sound was heard at Alvechurch and Brinscombe, places which are forty-four miles apart.[1]

*Central England Meteorite*, November 20, 1887.—At about 8.20 a.m. a loud sound, accompanied in many cases by a distinct trembling or shaking of houses, was heard over a large area, chiefly in the counties of Cambridge, Bedford, Hertford, Buckingham, Oxford and Berkshire. Many observers at once attributed the phenomena to an earthquake, and Mr. H. G. Fordham, who has made a careful study of them,[2] commenced his inquiries under that impression. It soon appeared, however, that the disturbance proceeded from the air rather than from the ground, and this fact, together with the actual observation of a meteor at the time mentioned, placed its true origin beyond doubt.

The accompanying map is, in part, a reproduction of that prepared by Mr. Fordham; but my object being somewhat different from his, I have added some details and omitted others. Every place where the sound was heard without any mention being made of an accompanying tremor is denoted by a small cross. If the concussion was strong enough to make doors, windows, and other loose objects rattle, the place of observation is shown by a large dot; if the tremor only is mentioned, without any other indication of its intensity, it is marked by a small dot. The sound-area as thus drawn is about 105 miles in length and nearly forty miles in breadth.

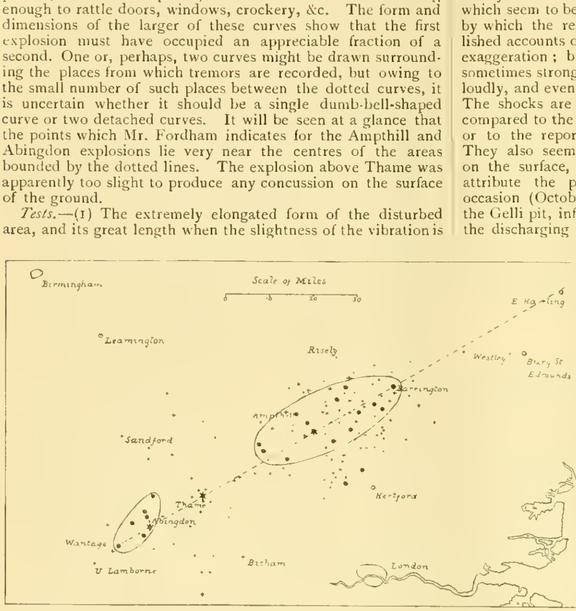
From the grouping of the places, where the sound was especially loud and definite, Mr. Fordham believes that the track of the meteorite would probably be best defined by a line drawn from Barrington (near Cambridge) to Wantage. Assuming this line

[1] NATURE, vol. xlix., 1894, pp. 324-325; *The Times*, January 29, 31, 1894.
[2] The meteorite of November 20, 1887.—*Hertfordshire Nat. Hist. Soc. Trans.*, vol. v., 1888, pp. 33-62.

to be correct, the observation of the meteor from Hertford would show that it was first seen when at a height of about thirty miles above East Harling, in the south of Norfolk, and that when above a point (indicated on the map by a star) about south-east of Ampthill, an explosion occurred which broke off part of the crust of the meteorite. At two other points (also marked by stars) in the neighbourhoods of Thame and of Abingdon and Wantage, explosions seemed to have occurred, the latter terminating the course of the meteorite.

Some additional evidence is furnished by the grouping of the places where the sound of the explosion was accompanied by a distinct tremor. The two dotted curves on the map bound all places (with two exceptions) where the concussion was strong enough to rattle doors, windows, crockery, &c. The form and dimensions of the larger of these curves show that the first explosion must have occupied an appreciable fraction of a second. One or, perhaps, two curves might be drawn surrounding the places from which tremors are recorded, but owing to the small number of such places between the dotted curves, it is uncertain whether it should be a single dumb-bell-shaped curve or two detached curves. It will be seen at a glance that the points which Mr. Fordham indicates for the Ampthill and Abingdon explosions lie very near the centres of the areas bounded by the dotted lines. The explosion above Thame was apparently too slight to produce any concussion on the surface of the ground.

*Tests.*—(1) The extremely elongated form of the disturbed area, and its great length when the slightness of the vibration is taken into account; the detached isoseismal lines in those cases where there are two or more explosions. (2) The sound is far more prominent than the vibration, which is never the case all over the disturbed area of an earthquake unless that area is a very small one; also, the sound-area overlaps the disturbed area on all sides, and this is only the case with very weak earthquakes. (3) The character of the sound, often consisting of a series of explosions. (4) The obvious transmission of the sound-vibrations through the air. Though I have examined many thousands of earthquake-records, the sound is almost uniformly described by the writers as of underground origin. (5) The vibration of doors, windows, &c., is evidently a concussion due to the impact of air-waves. Occasionally a tremor is actually felt, but, as in the case of a heavy thunder-clap, this is no doubt due to the same cause. (6) The evidence of barograms may be useful in those cases where there is reason to believe that the movement is not due simply to the disturbance of the recording arm. (7) The actual observation of the meteor, or, if the sky be covered, of the glare of its light through the clouds.




### ROCK-FALLS IN UNDERGROUND CHANNELS.

The fall of rock-masses in underground channels was for long regarded with favour as a possible cause of earthquakes.[1] No great and widely-felt shock would now be attributed to such a cause, but there are certain local earth-shakes which may reasonably be accounted for in this manner. The fall of a heavy mass of rock is evidently capable of producing the observed effects such as are described below. For example, towards the close of last century, one or more of the great upright stones of Stonehenge suddenly fell. According to Mallet, "the shock felt in all the neighbouring hamlets was so great that for some time, until the cause was discovered, it was thought to have been an earthquake, as in fact it was, though not produced by natural causes."[1]

*Earth-Shakes in the Rhondda Valley.*—In the Rhondda Valley in south-east Wales, there are frequent earth-shakes, which seem to be due to rock-falls in the deserted pit-workings by which the region is honeycombed. In many of the published accounts of these disturbances, there is evidently much exaggeration; but there can be no doubt that the shocks are sometimes strong enough to cause windows and doors to rattle loudly, and even to give rise to a distinct rocking sensation. The shocks are accompanied by a noise which is generally compared to the thud produced by the fall of a heavy body, or to the report of a colliery explosion or a distant gun. They also seem to be felt quite as severely in the mines as on the surface, and alarm the men at work, who naturally attribute the phenomena to an explosion. On a recent occasion (October 16, 1896), a miner, who was working in the Gelli pit, informs me that he heard one loud boom, like the discharging of a shot in rock, followed by a slight rumbling; "but others working in the same pit had a severe shaking, the tools springing off the floor, the dust rising in clouds off the bottom." Again, in the three cases (June 22, 1889; April 11, 1894; and October 16, 1896) which I have studied, the disturbed areas are roughly circular, and the diameters are small, being, respectively, about one, six and three miles in length; and the second of these is said to have been by far the strongest recently felt in the district. The centres of the three areas are close together, the two extreme ones being five miles apart, and they follow roughly the line of the Rhondda Valley. Now, the rapid diminution in intensity from the centre outwards implies a very shallow focus; the shock and sound are by nature such as would be produced by the fall of a heavy mass of rock, underground passages exist at no great depth, and subsidences at the surface are known to occur, for houses have been destroyed in this way in many parts of the district. The evidence in favour of the view that the so-called earthquakes are spurious is therefore strong; but the crucial test, that of finding the fallen mass, has, so far as I know, never yet been satisfied.

*Earth-Shakes at Sunderland.*—A similar, though less artificial, origin may be urged with equal force for the remarkable series of earth-shakes which are occasionally felt in and near Sunderland. These have been described and the theory of their origin clearly worked out in an admirable paper[2] by Prof. G. A. Lebour, from which the following details are taken. The disturbances consist of sudden shakes, strong enough to make crockery and windows rattle, often, but not always, accompanied by loud noises and dull rumbles. They are, moreover, singularly local, being almost entirely confined to the south-west part of the town, and, apparently, to certain linear bands within that part. As in the case of the Rhondda Valley shocks, the foci must be situated at slight depths, and the phenomena are such as would result from underground rock-falls. It is also certain that the necessary channels exist, for the magnesian limestone, on which Sunderland is built, is simply riddled with cavities of every size and shape, the origin of which is not far to seek. In the midst of the hardest and most compact portions of the limestone, there occur masses of soft pulverulent earthy

[1] I need not do more than refer to the subsidences in certain well-known districts which are almost entirely undermined by coal-pits or brine channels. The disturbance is sometimes described as resembling a severe earthquake, but there could hardly be more than a momentary confusion between the two phenomena.

[1] *Roy. Irish Acad. Trans.*, vol. xxi., 1848, p. 63.

[2] "On the Breccia-Gashes of the Durham Coast and some Recent Earth Shakes at Sunderland." (North of England Inst. of Min. Eng. *Trans.* vol. xxxiii., 1884, pp. 165–174.) See also *Geol. Mag.*, vol. ii., 1885, pp. 513–515.

matter, which are readily removed by the mechanica action of percolating rain-water. In such naturally-formed gullets run the feeders of water that are met with in sinking through the magnesian limestone, and these feeders, by chemical action, must cause much additional destruction of the rock. Quite apart from the water which runs off into the sea, that which is pumped up annually by the local water company is estimated to contain lime and magnesia in solution corresponding to nearly forty cubic yards of solid rock.

It seems evident that masses of rock must from time to time fall from the roofs of channels so formed. But we are not here left entirely to conjecture, for, at numerous points along the Durham coast, sections of such channels are exposed that are entirely filled up by angular fragments of the very rock which forms the cliff, and bound together by a cement of the same material. The "breccia-gashes," as they have been termed by Prof. Lebour, vary in width from a few feet to many yards; they are almost invariably narrow at the bottom, and generally wide at the top. "In some cases the broken fragments within the fissures can be traced graduating through semi-brecciated portions of beds to wholly undisturbed strata in the walls or fissure-cheeks. When the top of a fissure is exposed in section, the breccia is also seen usually to pass gradually upwards, first into semi-brecciated matter, and finally to undisturbed or only slightly synclinal beds bridging over the mass of broken rock. When the entire transverse section of a fissure is exposed, it is seen to be a deep V-shaped ravine or gullet, tapering to a point below, and the rocks below it are wholly undisturbed" (p. 166).

*Tests.*—Individual spurious earthquakes belonging to this class are the most troublesome of all to investigate, for, in most cases, we have to rely on circumstantial evidence alone. The principal tests will be obvious from the above descriptions. They are: (1) the small disturbed area and the comparatively great intensity near its centre; (2) the nature of the shock and sound; (3) the known or inferred honeycombed structure of the district, and the occurrence at other times of subsidences at the surface.

Charles Davison.

## REPORT OF THE LONDON TECHNICAL EDUCATION BOARD.

The annual report of the Technical Education Board of the London County Council was recently presented to the Council. The following paragraphs of the report, referring to the Board's relations with the Department of Science and Art and with the new London University, are abridged from the *Technical Education Gazette.*

### *Relations with the Department of Science and Art.*

The Council has been recognised by the Department of Science and Art as the local authority responsible for science and art instruction within the area of the County of London in accordance with Clause VII. of the Science and Art Directory. The powers and duties which such recognition may give have been delegated by the Council to the Board in the same way as the powers conferred by the Technical Instruction Acts were delegated. Ever since the passing of the Technical Instruction Act in 1889, the Science and Art Department has been in the position of the central authority for technical instruction, and the county councils and county borough councils have been in the position of local authorities for technical instruction. Clause VII. introduced a certain readjustment of duties as between the central authority and the local authorities. No new powers are conferred outside the provisions of the Technical Instruction Acts, but the clause provides for some of the functions under those Acts which have hitherto been discharged by the central authority being delegated to the local authority. Over thirty counties and county boroughs have availed themselves of the clause, and it is stated by those who have had experience of the working of the new system that it is advantageous both to particular schools and to the district generally.

The principal benefits which the Board anticipates from the working of Clause VII. in London are the following:—

(*a*) Increased facilities for coordinating and organising science and art work in accordance with the particular needs of each locality.

(*b*) Greater regularity and promptitude in the payment of the grants earned on the Department's examinations.

(*c*) Increased opportunities for urging upon the Department such modifications in their courses of instruction as may be specially required by the circumstances of London schools and institutions.

The Technical Instruction Act of 1889 affords, perhaps, the first legislative example in educational work of adaptation to special local requirements. In the definition of technical instruction the Act includes "any other form of instruction (including modern languages and commercial and agricultural subjects), which may for the time being be sanctioned by that Department [the Department of Science and Art] by a minute laid before Parliament and made on the representation of a local authority that such a form of instruction is required by the circumstances of its district." The Technical Instruction Act having provided for the creation of powerful and disinterested authorities for the conduct and supervision of technical instruction over large areas, Parliament, in the words quoted above, expressed its willingness to give to these authorities an important part in determining the particular field of education which should come within their influence, thus enabling both the matter and the manner of education to be adapted to local needs. It is reasonable to suppose that the same principle will now apply in connection with the subjects of technical instruction which are defined by detailed syllabuses in the Science and Art Directory. The Department has already expressed its willingness to meet the wishes of the local authorities in respect of several administrative details.

### *The New University of London.*

In order to formulate the Board's views with regard to the new University, a special sub-committee was last year established for the purpose of investigating the whole subject and reporting to the Board as to the steps which might be deemed necessary for making representations to the Commissioners on any points in which the Board might be specially interested. In pursuance of this policy, the Board forwarded to the Commissioners an expression of its views upon certain matters. In particular, the Board urged upon the Commissioners the desirability of recognising separate faculties for engineering and for economic and commercial science. The Board's representations were supported by similar expressions of opinion from other quarters, and the Commissioners have come to the decision to adopt the policy which the Board favoured. In the draft statutes which they have prepared for the new University, they have decided to provide for (*a*) a special faculty of engineering, and (*b*) a special faculty of economics and political science (including commerce and industry). There is little doubt that the establishment of these faculties will give considerable encouragement to the technical and commercial work in which the Board is specially interested. Recognising the importance of developing the higher departments of these branches of study, the Board has undertaken to allocate to the University out of the funds from time to time placed at its disposal by the Council an annual sum of 2500*l*. towards the maintenance of the faculty of engineering in the new University, and a further sum of 2500*l*. towards the maintenance of the faculty of economics and political science (including commerce and industry), on condition that satisfactory arrangements are made in the constitution of the University with regard to evening students, and the recognition and admission to th several faculties of duly qualified teachers in the polytechnics.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

Oxford.—The following is the speech delivered by the Public Orator, Dr. W. W. Merry, on the occasion of his presenting Dr. R. Trimen, F.R.S., for the honorary M.A. degree on May 16:—

Praesento vobis Ronaldum Trimen, Societatis Regiae Socium, nuper autem Societatis Entomologicae apud Londinium Praesidem. Vir insignis, qui notitiam suam officiosissime impertiendo de Universitate Oxoniensi optime meruit, diu in Africa australi est commoratus, non utique ut gemmas et aurum fodinis erueret neque ut cum Batavis litem sereret, sed ut Naturae arcana altius scrutaretur ac praesertim insectorum inexploratas consuetudines patefaceret.

"In tenui labor, at tenuis non gloria."

Quotus enim quisque mirum illud ingenium quo Natura inermes bestiolas instruxerit vel diligentius investigavit vel exposuit

luculentius? Quis clarius illustravit raram sollertiam qua minuta animalium genera, vel ut compares alliciant vel ut infestas hostium incursiones arceant, nunc colores mutare, nunc novum aliquod simulacrum assumere, nunc etiam sexum mentiri videantur? Quae quidem omnia si primo visu parvi momenti esse habeantur, eadem, nisi magnopere fallor, oculis subjecta fidelibus et summa accuratione tractata, immane quantum prosunt ad intimas vitae leges enodandas. Quae cum ita sint, haud dubitarem eruditissimi auctoris C. Plinii Secundi verba citare de insectorum corporibus scribentis: "In his tam parvis atque tam nullis quanta vis, quae ratio, quam inextricabilis perfectio! . . . Sed turrigeros elephantorum miramur humeros, taurorumque colla et truces in sublime jactus, tigrium rapinas, leonum jubas, cum rerum natura nusquam magis quam in minimis tota sit; et in contemplatione naturae nihil possit videri supervacuum."

Praesento vobis ornatum et excultum virum Ronaldum Trimen, qui et ipse "Naturalis Historiae Libris" tam laudabile incrementum addidit, ut admittatur ad gradum Magistri in facultate Artium, honoris causa.

CAMBRIDGE.—Mr. W. Chawner, Master of Emmanuel College, is to be Vice-Chancellor during the ensuing academical year.

Mr. R. C. Punnett, of Caius College, has been nominated to occupy the University table at the Marine Biological Laboratory at Plymouth.

The Chemical, Pathological, and Anatomical Laboratories will be open during the ensuing Long Vacation, and a number of special courses of instruction will be given in July and August.

The electors to the new chair of Agriculture are the Right Hon. W. H. Long, Mr. A. E. Shipley, Dr. D. MacAlister, Prof. Liveing, Sir J. H. Gilbert, Prof. Foster, Prof. Marshall Ward, and Sir Walter Gilbey.

IT is satisfactory to know that the value of scientific education and research in agriculture is becoming more and more recognised by foremost agriculturists. Mr. Boyd-Kinnear refers to these matters in a contribution to the *Morning Post*, and to the lack of interest taken in them by British farmers. He points out that a knowledge of the scientific principles of agriculture is of fundamental importance, and that what should be taught in our schools are the sciences on which farming rests—physics, chemistry, mechanics, and the physiology of plants and animals. The sound remark is made that for a farmer to work without this kind of knowledge, is much the same as if a doctor were educated by being shown cases in a hospital before he had learned anything of anatomy or the nature of drugs. In order to know agriculture, it is necessary to understand first of all the elements and the action of the soil and the air, and the operations of life. But all that the most learned in science know of these things is infinitely small compared with the amount that is yet unknown. There is, therefore, urgent need, not only for teaching what is known, but also for learning more. That is, we ought to have both schools where the fundamental sciences which agriculture involves are taught, and also institutions for further research into the secrets yet undiscovered.

Referring to agricultural research stations, Mr. Boyd-Kinnear remarks:—In all countries but England these are provided and liberally maintained by the State. In Germany there are, and have been for the last half-century, no fewer than sixty-seven agricultural teaching and research stations. France has fifty-three, Austria thirty-five, and even Russia has fourteen. The other European States, including countries which we call so backward as Spain and Portugal, have sixty-one among them. The United States have fifty-four, these being supported by the individual States; Canada has several, while Brazil, Japan, and Java have each one! England has—none! none, that is, with State endowment. During the last few years, the County Councils of Sussex, Yorkshire, Bucks, and Durham have established teaching colleges, but without any adequate provision for research. There are also the privately-conducted colleges of Cirencester, Downton, and one or two others, while the half-century of inquiries conducted by Sir John Lawes is deserving of grateful acknowledgment. But isolated and private effort is wholly inadequate to meet the want, or even to direct public attention to it.

## SOCIETIES AND ACADEMIES.

### LONDON.

Royal Society, May 4.—"An Observation on Inheritance in Parthenogenesis." By Ernest Warren, D.Sc., University College, London. Communicated by W. F. R. Weldon, F.R.S.

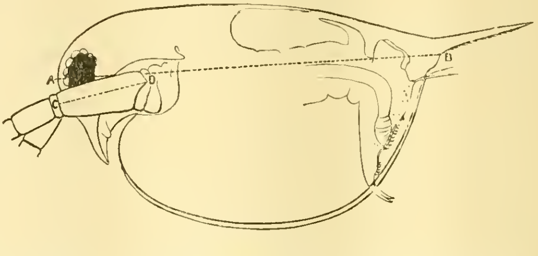
If the hypotheses of Weismann on heredity and variation be founded on fact, then it should follow that offspring produced by parthenogenesis should exhibit little or no departure from their parthenogenetic mother.

It appeared an easy investigation to test this supposition by direct measurement. For this purpose, *Daphnia magna* (Straus) was chosen.

On twenty-three Daphnia, the following measurements were made: (1) the length of the protopodite of the second antenna of the right side (C D see Fig.), and (2) the total length of the body (A B). The first dimension was expressed in thousandths of the second, because these animals (like very many invertebrates) continue to grow throughout life. The broods, amounting in all to ninety-six young, produced by the twenty-three mothers (themselves originating by parthenogenesis), were similarly measured.

The children of the same parthenogenetic family were now seen to vary considerably. A correlation table between the mothers and offspring was prepared, and from it the coefficient of correlation was found to be ·466. The standard deviation (S.D.) of an array of offspring was 5·22 thousandths of the body length: if we express it as a kind of coefficient of variation

we have $\dfrac{\text{S.D. of array}}{\text{Mean of all the offspring}} \times 100 = 3{\cdot}06.$




Thus *in parthenogenesis there is very considerable variability among the offspring*, but whether there is less or more than in sexual reproduction the present measurements do not show.

Dr. Galton and Prof. Pearson have shown that in Basset hounds, stature in man, &c., the correlation between father or mother and offspring approaches the theoretical value ·3, while between mid-parent and offspring it approaches ·424, and the coefficient of regression of offspring on mid-parent is about ·6.

Here, in the Daphnia, the coefficients of correlation and regression were respectively ·466 ± ·054 and ·619 ± ·081. Thus it would *seem* as though in the matter of inheritance a parthenogenetic mother acts as a mid-parent. The subject, however, requires much further elucidation, and the hypothesis is about to be tested on another parthenogenetic animal.

Geological Society, May 24.—W. Whitaker, F.R.S., President, in the chair.—The President called attention to the issue of vol. iii. of Hutton's "Theory of the Earth," and said that the thanks of the Fellows were due to Sir A. Geikie for having edited and annotated most carefully this work. The volume was printed from a previously unpublished manuscript which had been for many years in the possession of the Society: its contents were extremely interesting, and it supplemented the previous volumes by the inclusion of an index to the whole of the work, prepared by Sir A. Geikie.—Prof. Seeley exhibited a cast from a footprint obtained by Mr. H. C. Beasley from the Trias at Stourton. The impression is about 1½ inch long, and nearly as wide. The cast has been treated by oblique illumination, so as to display its osteological structure by means of the shadows thus thrown. All the claws are directed outwards, as in a burrowing animal. The form of the foot

resembles that of a monotreme mammal rather than that of any existing reptile. There appears to be a slender pre-pollex including three bones. The only other example of this structure in the Trias is in the Theriodont reptile *Theriodesmus*, in which it is less definite. This character may add to the interest of other footprints from Stourton, which in the form of the foot approximate to Anomodont reptiles from the Karoo Beds of Cape Colony.—On the distal end of a mammalian humerus from Tonbridge, by Prof. H. G. Seeley, F.R.S. The bone described in this communication was found in 1898 by Mr. Anderson on the bank of the river Medway, near Tonbridge. It was seen projecting from reconstructed rock which contained fragments of flints among other materials. Traces of matrix at the distal end show that the specimen has been derived from quartz-sand bound together with limonite, such as might occur in the Hastings Sand, Wealden Clay, or Lower Greensand. Conditions of mineral structure and osteological character incline the author to believe that the bone was originally contained in the Wealden Clay. The fossil is 4 inches long, and indicates a humerus which may have been 6 inches in length when perfect, as large as that of a wolf but smaller than that of a bloodhound. The form of the shaft precludes any comparison with the carnivora, and indicates a resemblance to ungulate types. When the bone is held vertically and seen from the front, the condyles are oblique—a character not observed in any other animal. The weight of evidence appears to incline towards reference of the fossil to the Artiodactyla, but it probably indicates a new family type.—On evidence of a bird from the Wealden Beds of Ansty Lane, near Cuckfield, by Prof. H. G. Seeley, F.R.S. A fragment of bone found, by Mr. Neville Jones, a member of the London Geological Field Class, embedded in sandstone was identified by the author as probably the distal end of the femur of a bird. The external condyle is not only larger and deeper than the inner, but is more prolonged distally—perhaps the most distinctive avian character of the bone. *Colymbus* is the only existing bird to which the fossil makes any approximation, but the resemblance is distant and not suggestive of near affinity, and it is interesting that the cretaceous birds show so marked an affinity with that type. The resemblances of the dinosaurian and crocodilian femora with this type are such that almost every individual feature of the bone can be paralleled in some fossil referable to these groups, but there are no British dinosaurs of so small a size or possessing some of the marked features shown by this bone.—Notes on the rhyolites of the Hauraki Goldfields (New Zealand), by James Park and Frank Rutley; with analyses by Philip Holland. Part i. of this paper, by Mr. J. Park, gives a description of the rhyolites as seen in the field. After a rest from volcanic action during the secondary period, the tertiary eruptions burst forth and were more widespread than those of recent times. In the Hauraki Peninsula, the basement palæozoic rocks are covered by richly fossiliferous marly clays and limestone of Lower Eocene age, and these by a vast accumulation of andesitic lavas and tuffs, in places 3000 feet thick. These andesites are the gold-bearing rocks of the district, and they are succeeded by rhyolitic lavas and ashes. Both andesites and rhyolites were influenced by solfataric action, resulting in siliceous deposits rich in gold and silver. The rhyolites rest on rocks probably of Upper Miocene age, and are followed by Pleistocene and recent deposits; so that they probably range from older to newer Pliocene in date. Part ii. contains the observations of Mr. Rutley on the petrology of the rhyolites. The rocks present occasional occurrences of perlicity, and the lithoidal types sometimes owe their characters to subsequent devitrification, sometimes to the effect of cooling on, or immediately after, eruption. Reheating has at times reduced the felspars to the condition of felspar-glass. Although plagioclase-felspar is common, the analyses indicate that the series must be retained with the rhyolites, it being quite possible that some of these minerals may have been derived from the andesites.—On the progressive metamorphism of some Dalradian sediments in the region of Loch Awe, by J. B. Hill, R.N. (communicated by Sir A. Geikie, F.R.S.). The region under discussion contains two principal series of rocks, passing one into another without a break, and conveniently referred to the Dalradian System: (1) The Ardrishaig Series (phyllites and fine-grained quartzites). (2) The Loch Awe Series (black slates, limestones, grits, and quartzites). The latter series lies in a gentle trough of the former. Even in their most altered state, the clastic nature of the rocks of the Loch Awe Series is apparent. Both series are pierced by innumerable intrusive sills of epidiorite, hornblende-schist, and chlorite-schist, modified diorites and gabbros, which effect contact-metamorphism in the bordering sediments. Intrusive rocks of post-schistose date also occur, like the Glenfyn granite, the granite of Ben Cruachan, and smaller masses of granite, monzonite, hyperite, ultrabasic rocks, quartz-porphyries, felspar-porphyries, porphyrites, and lamprophyres; these are in their turn cut by dolerite and basalt-dykes. All these rocks exhibit progressive metamorphism when traced towards the north-east and towards the Central Highlands, a character best seen in the loop formed by the rocks near the head of Loch Awe. Although the author does not go very fully into the question of the causes of the progressive metamorphism exhibited in tracing these rocks towards and into the Central Highland schists, he had reason to suspect that "the intense regional type of metamorphism was linked with the same phenomena that afterwards resulted in the irruption of the granite-masses."

### PARIS.

**Academy of Sciences**, May 29.—M. van Tieghem in the chair.—On isothermal surfaces, by M. Gaston Darboux.—On the laws of pressures in guns, by M. Vallier. A theoretical discussion of the distribution of pressure from point to point of the barrel during firing.—On cyclic pencils which contain a system of geodesics, by M. C. Guichard.—On the series of Dirichlet, by M. Lerch.—On the true polarisation of dielectrics placed within an electric field, by M. H. Pellat. The hypothesis is advanced that polarisation is not instantaneous; but that a dielectric, solid or liquid, placed suddenly in an electric field, takes a polarisation which increases with the time, reaching a maximum asymptotically. If the field ceases, the polarisation decreases gradually, becoming zero at the end of a certain time, theoretically infinite. The results of an experimental study are in agreement with this hypothesis.—Polymerisation of abnormal vapours: nitrogen peroxide and acetic acid, by M. A. Leduc. In a previous paper, the author has shown that the variations in the density of chlorine with temperature are in perfect agreement with the theory of corresponding states, and the assumption that a dissociation of chlorine molecules has taken place is unnecessary. An application of the same method to the cases of nitrogen peroxide and acetic acid shows that the molecule is clearly dissociated.—On the measurements, in terms of a wave-length as unit, of a quartz cube, of 4 cm. length of side, by MM. Ch. Fabry, J. Macé de Lépinay, and A. Perot. The measurement was effected by means of the interferential method previously described, the variations between the individual readings being of the order of 1 in 1,000,000.—Bravais points and poles, by M. Pierre Lefebvre.—On the estimation of hydrogen phosphide in gaseous mixtures, by M. A. Joannis. A solution of copper sulphate cannot be employed to estimate hydrogen phosphide in gaseous mixtures, except in the absence of gases absorbable by copper salts. The copper sulphate solution must always be employed in considerable excess.—Separation and estimation of traces of chlorine in presence of a very large excess of bromide, by M. H. Baubigny. The method of copper sulphate and potassium permanganate is employed, and analyses of samples of potassium bromide sold as pure showed that a trace of chlorine was invariably present, 0·1 per cent. of chlorine being the minimum.—Properties of some mixed haloid salts of lead, by M. V. Thomas.—On the quantitative separation of cerium, by MM. G. Wyrouboff and A. Verneuil. The method suggested is based upon the solution of the mixture of oxides in nitric acid, and subsequent polymerisation of the oxide in presence of sulphuric acid. The test analyses given are very satisfactory.—The enantiomorphic structure of *l*- and *r*-benzylidene-camphors as revealed by corrosion figures, by M. Minguin.—Mixed combinations of phenylhydrazine and another organic base with certain metallic salts, by M. J. Moitessier.—Study of some oxymethylenic derivatives of cyanacetic ethers, by M. E. Grégoire de Bollemont.—Centrosome and fecundation, by M. Félix Le Dantec.—On the variations and specific grouping of the American Peripatæ, by M. E. L. Bouvier.—Spontaneous asphyxia and the production of alcohol in the deeper tissues of ligneous stems under natural conditions, by M. Henri Devaux. A study of the respiratory coefficients of the internal layers of certain plant stems showed that the ratio $CO_2/O_2$ increases rapidly with the temperature. This increase of carbon dioxide, according to the

author, can only arise from a true fermentation, and in accordance with this view alcohol was obtained from such stems.—The guidroa, the caoutchouc tree of Madagascar, by M. Henri Jumelle. An examination of the guidroa showed that it clearly belongs to the genus *Mascarenhasia*; but, as it does not exactly agree with any of the fifteen or sixteen species actually known, the name *M. velutina* is proposed for the plant.—On the parasitism of *Ximenia americana*, by M. Edouard Heckel.—On some rhyolites from Somaliland, by M. A. Lacroix.—On the eruptive rocks of Cape Blanc (Algeria), by MM. L. Duparc and E. Ritter. Microscopic and chemical examination of the volcanic rocks of Cape Blanc show them to be neo-volcanic quartz-porphyry of a basic character.—On the existence in the blood of animals of a substance preventing the coagulation of milk, by M. A. Briot. Blood serum from the horse contains a substance capable of neutralising the effects of a certain quantity of rennet. This substance is of a diastatic nature, since it cannot be dialysed, is destroyed by heat, and can be precipitated by ammonium sulphate and by alcohol.

## DIARY OF SOCIETIES.

*THURSDAY*, JUNE 8.

ROYAL SOCIETY, at 4.30.—Meeting for Discussion.—*Subject*: On Preventive Inoculation: introduced by M. Haffkine.

MATHEMATICAL SOCIETY, at 8.—On Solitary Waves, Equivoluminal and Irrotational, in an Elastic Solid: Lord Kelvin, G.C.V.O.—On Several Classes of Simple Groups: Dr. G. A. Miller.—The Transmission of Stress across a Plane of Discontinuity in an Isotropic Elastic Solid and the Potential Solutions for a Plane Boundary: Prof. J. H. Michell.—On Theta Differential Equations and Expansions: Rev. M. M. U. Wilkinson.—Finite Current Sheets: J. H. Jeans.—On a Congruence Theorem having reference to an Extensive Class of Coefficients; and on a Set of Coefficients analogous to the Eulerian Numbers: Dr. Glaisher, F.R.S.—(1) The Reduction of a Linear Substitution to its Canonical Form; (2) On the Integration of Systems of Total Differential Equations: Prof. A. C. Dixon.

*FRIDAY*, JUNE 9.

ROYAL ASTRONOMICAL SOCIETY, at 8.—Further Investigation concerning the Position Error affecting Eye-Estimates of Star Magnitudes: A. W. Roberts.—Equatorial Comparisons of Jupiter, Uranus and Neptune with certain Stars in Newcomb's Standard Catalogue: John Tebbutt.—Note on the Nebula N.G.C. 6535: W. H. Robinson.—*Probable Paper*: An Ephemeris of Two Situations in the Leonid Stream: G. Johnstone Stoney.

PHYSICAL SOCIETY, at 5.—On the Distribution of Magnetic Induction in a Long Iron Bar: C. G. Lamb.—On the Absolute Value of the Freezing-Point: J. Rose-Innes.

MALACOLOGICAL SOCIETY, at 8.—Description of a New Species of *Unio* from the River Pahang: E. A. Smith.—Notes on Holocene Deposit at the Horseshoe Pit, Colley Hill, Reigate: Rev. R. Ashington Bullen.—Anatomical Notes on *Medyla insculpta*, Pfr.: Henry Suter.

*SATURDAY*, JUNE 10.

EOLOGISTS' ASSOCIATION.—Excursion to Rickmansworth and Harefield. Directors: W. Whitaker and John Hopkinson.

*MONDAY*, JUNE 12.

RÖNTGEN SOCIETY, at 8.—Portable Röntgen Apparatus for Field and Ward Work, to be demonstrated and described by Major Beevor, J. Hall Edwards, and H. W. Cox.—A New Stereoscope to be demonstrated for Mr. Gregory by F. W. Watson Baker.—Dr. Walsh will also show a New Stereoscope.

*TUESDAY*, JUNE 13.

ANTHROPOLOGICAL INSTITUTE, at 8.30.—Prehistoric Man in the Neighbourhood of the Kent and Surrey Border: Neolithic Age: George Clinch.

ROYAL PHOTOGRAPHIC SOCIETY, at 8.—Acetylene: Prof. Vivian B. Lewes.

*THURSDAY*, JUNE 15.

ROYAL SOCIETY, at 4.—Prof. A. Michelson will read a Paper.—The Colour Sensations in Terms of Luminosity: Captain Abney, F.R.S.—A Comparison of Platinum and Gas Thermometers at the International Bureau of Weights and Measures at Sèvres: Dr. J. A. Harker and Dr. P. Chappuis.—On a Quartz-Thread Gravity Balance: R. Threlfall, F.R.S.—On the Orientation of Greek Temples, being the Results of some Observations taken in Greece and Sicily, in May, 1898: F. C. Penrose, F.R.S.—A Preliminary Note on the Life-History of the Organism found in the Tsetse Fly Disease: Dr. H. G. Plimmer and Dr. T. Rose Bradford, F.R.S.—And other Papers.

LINNEAN SOCIETY, at 8.—Contributions to the Natural History of Lake Urmi and its Neighbourhood: R. T. Günther.—A Systematic Revision of the Genus Najas: Dr. A. B. Rendle.—On the Anatomy and Systematic Position of some Recent Additions to the British Museum Collection of Slugs: Walter E. Collinge.—The Edwardsia Stage of Lebrunia, and the Formation of the Œsophagus and Gastro-cœlomic Cavity: J. E. Duerden.

CHEMICAL SOCIETY, at 8.—Ballot for the Election of Fellows.—On the Decomposition of Chlorates, with special reference to the Evolution of Chlorine and Oxygen: W. H. Sodeau.—The Action of Hydrogen Peroxide on Formaldehyde: Dr. A. Harden.—Homocamphoronic and Camphononic Acids: A. Lapworth and E. M. Chapman.—Action of Silver Compounds on α-Dibromocamphor: A. Lapworth.—The Colouring Matter of Cotton Flowers: A. G. Perkin.—Experiments on the Synthesis of Camphoric Acid: H. A. Auden, W. H. Perkin, jun., and J. L. Rose.—Methylisoamylsuccinic Acid, Part I.: W. T. Lawrence.

## BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—The Hereford Earthquake of December 17, 1896: Dr. C. Davison (Birmingham, Cornish).—Physikalisches Praktikum: E. Wiedemann u. H. Ebert, Vierte Auflage (Braunschweig, Vieweg).—Tables for Quantitative Metallurgical Analysis: J. J. Morgan (Griffin).—Royal University of Ireland Exam. Papers, 1898 (Dublin).—Year-Book of Photography (9 Cecil Court).—A Country Schoolmaster: James Shaw, edited by Prof. R. Wallace (Edinburgh, Oliver).—I Batteri Patogeni: Dr. N. Ottolenghi (Torino, Rosenberg).—Sieroterapia e Vaccinazioni Preventive contro la Peste Bubbonica: Dr. A. Lustig (Torino, Rosenberg).—The Elements of Practical Astronomy: W. W. Campbell, 2nd edition (Macmillan).—Bergens Museum. Report on Norwegian Marine Investigations, 1895–97: Hjort, Nordgaard, and Grann (Bergen).—List of the Genera and Species of Blastoidea in the British Museum (Natural History) (London).—Chimie Végétale et Agricole: Prof. Berthelot, 4 Vols. (Paris, Masson).—Sewer Design: H. N. Ogden (Chapman).—The Steam Engine and Gas and Oil Engines: Prof. J. Perry (Macmillan).—The Dog: edited by Piepe and Furneaux (Philip).—An Account of the Deep-Sea Ophiuroidea collected by the R.I.M.S. Ship *Investigator*: R. Koehler (Calcutta).—Traité Élementaire de Mécanique Chimique: Prof. P. Duhem, Tome iv. (Paris, Hermann).—U.S. Geological Survey, 18th Annual Report, Part 2, Part 5 (Washington).

PAMPHLETS.—Die Methode der Variationsstatistik: G. Duncker (Leipzig, Engelmann).—Das Hypsometer als Luftdurckmesser, &c.: H. Mohn (Christiania, Dybwad).—Summary Report of the Geological Survey Department, 1898 (Ottawa).—Mauritius Magnetical Reductions: T. F. Claxton (Mauritius).—Protokoll über die vom 31 März bis 4 April, 1898 zu Strassburg i.E. abjgehaltene erste versammlung der Internationalen Aëronautischen Commission (Strassburg).—Picture Taking and Picture Making (Kodak Press).—Natural History of the Musical Bow: H. Balfour, Primitive Types (Oxford, Clarendon Press).—Thatsachen und Auslegungen in Bezug auf Regeneration: A. Weissmann (Jena, Fischer).—La Navigation a Vapeur sur le Haut Vang-Tse: R. P. S. Chevalier (Chang-Hai).

SERIALS.—Journal of the College of Science, Imperial University of Tokyo, Japan, Vol. xi. Part 2 (Tokyo).—Proceedings of the Washington Academy of Sciences, Vol. i. pp. 15–106 (Washington).—Johns Hopkins University, Studies in Historical and Political Science, Series xvii. Nos. 4 and 5 (Baltimore).—Monthly Weather Review, February (Washington).—Boletim do Musen Paraense, December (Pará).—Società Reale di Napoli, Atti della Reale Accademia delle Scienze Fisiche e Matematiche, serie ii. Vol. ix. (Napoli).—Contemporary Review, June (Isbister).—Century Magazine, June (Macmillan).—Humanitarian, June (Duckworth).—Photogram, June (Dawbarn).—Knowledge, June (Witherby).—Journal of the Chemical Society, June (Gurney).—Journal of the Marine Biological Association, June (Dulau).—Middlesex Hospital Journal, May (London).—Zeitschrift für Physikalische Chemie, xxix. Band, 1 Heft (Leipzig).—Journal of Botany, June (West).—Madras Government Museum, Bulletin Vol. 2, No. 3 (Madras).—An Illustrated Manual of British Birds: H. Saunders, 2nd edition, Parts 16 to 20 (Gurney.)—Fortnightly Review, June (Chapman).—Scribner's Magazine, June (Low).—Anglo-American Magazine, June (Anglo-American Publishing Company).

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THURSDAY, JUNE 15, 1899.

## THE ANTHROPOLOGY OF BADEN.

*Zur Anthropologie der Badener; Bericht über die von anthropologischen Kommission des Karlsruher Altertumsvereins an Wehrpflichtigen und Mittelschülern vorgenommenen Untersuchungen.* By Otto Ammon. Pp. xvi + 707. Maps 15. (Jena: Gustav Fischer, 1899.)

FOR many years the distinguished worker, Dr. Ammon, has been conducting an anthropological survey of the Grand-duchy of Baden in such an exhaustive and detailed manner as cannot fail to excite the admiration of all interested in this branch of science. A considerable proportion of his investigations has been already published and incorporated in anthropological text-books; but the present bulky volume gives the whole of his work in collected form, and embodies such generalisations as he considers can at present be safely attempted. For the final bearings of these investigations on the history and evolution of this portion of the Caucasian race, Dr. Ammon states, however, that further observations are necessary both in his own and in neighbouring countries. As a monument of patient research, many of the fruits of which others will pluck, the volume before us reflects the highest credit on the author and his fellow-worker, Dr. Wilser.

The observations have been carried out on recruits and school-children; the two series being kept quite distinct from one another. The country has been mapped out into districts, which were assiduously worked from 1887 to 1894, three out of the four chief districts having been undertaken by Dr. Ammon himself, while the fourth has fallen to the lot of Dr. Wilser. The number of individuals (which is very great) examined in each of the four districts is clearly indicated on the first of the admirable series of maps, which render both the physical features of the country and the results of the survey conspicuous at a glance. In view of the general gradual numerical diminution of blonds and the increase of brunettes as we pass from North to South Germany, Baden, as forming a long narrow strip running from the south towards the centre of the German empire, is admirably circumstanced to display the development of this law in the southern provinces.

In addition to describing the ordinary physical features of the country, the geological structure is likewise taken into account; and the effects of all natural surroundings on the population are thus considered in full detail. To enumerate all the anthropological features which have entered into the scheme of survey would be wearisome; and it must suffice to say that bodily stature (subdivided into total length, sitting-length, and leg-length), the proportions of the length to the breadth of the head, the colour of the eyes and hair, and the development of hair on parts of the person other than the scalp, are all taken into consideration. Especial attention is directed to the difference in the anthropological features of the inhabitants of the rural and urban districts; and, above all, to the changes in the population of the latter induced by immigration from the former. In these investigations, Dr. Ammon lays claim to having founded a new branch of anthropology.

Seeing that to render adequate justice to the scope of the work would require a considerable portion of a number of NATURE, it will be advisable to concentrate attention on a few features. Among these, the relative prevalence of long-heads and round-heads, of blonds and brunettes, in different districts is perhaps the most generally interesting.

At the commencement of the second section of the work we find some theoretical observations on the three "primitive" types of man met with in Europe. In common with many other modern anthropologists, such as Ripley and Sergi, the author recognises, firstly, the Mediterranean long-heads, of medium or small stature, with dark eyes, hair, and skin. Secondly, the North European long-heads, of tall stature, with blue eyes, blond hair, and fair skin. And, thirdly, the Alpine round-heads, whose stature is medium, with dark eyes, hair, and skin. And here it is important to notice that the author speaks of these simply as *types*, in contradistinction to *races*. He further observes that, owing to crossing, neither of the three types are common in their original purity in any district. In Baden itself, the population at the present day seems chiefly due to a mixture of the fair North European long-heads with the dark Alpine round-heads, the dark Mediterranean long-heads having failed to penetrate so far north in any great numbers.

The following table shows the number of individuals of each type met with among different classes of the population:

| Type. | Rural districts. | Immigrants. Small towns. | Immigrants. Large towns. | Town-born. Small towns. | Town-born. Large towns. |
|---|---|---|---|---|---|
| North European | 146 | 4 | 11 | 27 | 15 |
| Alpine | 26 | 3 | 5 | 3 | 1 |
| Mediterranean | 9 | 0 | 0 | 0 | 0½ |

The percentage from these works out as below:—

| | | | | | |
|---|---|---|---|---|---|
| North European | 1·45 | 0·77 | 1·25 | 1·94 | 2·54 |
| Alpine | 0·39 | 0·93 | 0·91 | 0·35 | 0·27 |
| Mediterranean | 0·09 | 0 | 0 | 0 | 0·08 |

From this we see that, while among the immigrants the North European type is rarer in the small and the large cities than in the rural population, among the town-bred the percentage rises so as to exceed that of the rural districts, this being most markedly the case in the large cities, where we have 2·54 per cent., against 1·45 in the country districts.

Respecting the Alpine type, we find the immigrants into small towns standing at 0·93 per cent., and at 0·91 in the larger cities, as against 0·39 in the rural districts; whereas in the town-bred class the percentage is less than in the country districts, the diminution being most marked in the case of large cities.

Here, therefore, we have evidence that the blond long-heads tend to gravitate towards the large cities, where they flourish; and that while there is also a large immigration of the dark round-heads, yet that these tend to die out in their urban homes. Certain details are also given with regard to the position occupied by the dark round-heads among their fellow-students in the schools; but into these it is impossible to enter on this occasion.

To a certain degree, these results accord with those arrived at by Monsieur de Lapouge in France, that anthropologist contending that the enterprising, restless, long-heads migrate in disproportionate numbers from the rural districts to the cities, where, however, they eventually tend to die out. As regards this dying-out, so far as the blond long-heads are concerned, Dr. Ammon's figures do not appear to accord with the French conclusions. And having regard to the objections which have been urged against the latter, our author is wise in stating (in the preface) the necessity of further investigations before definite deductions are attempted. He, however, thinks it quite possible that a "selection of long-heads" may be taking place; and expresses the "pious wish" that such may prove to be the case.

As regards the contention of the French investigator that the dark Mediterranean long-heads are the type best adapted for an urban existence, where they choke out the long-headed immigrants, Dr. Ammon[1] considers that this is not supported by the results of his own work; this showing a total absence of the Mediterranean type in three out of the four urban districts, while in the fourth they are considerably less numerous than in the rural districts.

Pursuing the same subject, we find, in the fourteenth chapter of the second part, Dr. Ammon giving a series of interesting details with regard to the differences of skull-proportion and hair-colour between the sons of the immigrants into the towns and those of their native-bred inhabitants. From these it appears that in the smaller towns the sons of town-bred people exceed those of immigrants both in stature, sitting-height, and length of leg, as well as in the leg-index. In large cities, on the other hand, while the first three factors in the former show a similar increase over the country-breds, the leg-index is less. From the country population to the immigrants, from the latter to the sons of immigrants, and from these again to the sons of the city-dwellers there is an increase in the number of long-heads, with a proportionate diminution of round-heads.

In both generations of the town-breds the relative number of blue eyes at first increases and then diminishes in cities of all sizes; in small towns the number of persons with blond hair does the same, while in large towns it remains constant. In the town generation the North European and the Alpine types tend to converge, and the Mediterranean type to disappear. It is in consequence of these changes that a preponderance of blond persons is not observable among the recruits drawn from towns.

Although the above are only a few of the interesting results of the author's investigations, it will be evident that they are of the utmost importance in regard to current French theories as to the general inferiority of the round-heads, and their absorption in cities of the superior long-heads. But, as even the mental superiority of the latter over the former type is by no means admitted by all anthropologists, it is evident that we are at present only on the very threshold of studies of this nature. That results likely to be of real service in connection with the problems presented by urban and rural populations, especially those connected with the present preponderating increase of the former, will ensue from the steady pursuit of such studies, can but be the earnest hope of all those interested (and who is not?) in the future of the higher branches of the human race. R. L.

[1] Page 448. It is a little difficult to reconcile Lapouge's statement as to the dying out of long-heads in cities (see Keane's "Man, Past and Present," p. 520) with his contention that the Mediterranean long-heads show a special suitability for such an existence.

## *LIMNOLOGY.*

*The Microscopy of Drinking-Water.* By G. C. Whipple, Biologist and Director of Mount Prospect Laboratory. Pp. xii + 300, and plates. (Brooklyn, N.Y.: Wiley and Sons. London: Chapman and Hall, Ltd., 1899.)

*Examination of Water (Chemical and Bacteriological).* By W. P. Mason, Professor of Chemistry, Rensselaer Polytechnic. Pp. 135. (New York: Wiley and Sons. London: Chapman and Hall, Ltd., 1899.)

THIS is an example of a class of books in the production of which the Americans are bidding fair to take a lead, the type of book which may be termed the popular practical scientific manual, where the limitation of the subject-matter and the thoroughness of treatment aimed at are worthy of the German, but devoid of that hair-splitting exactness which so often leads to obscurity; while the general style and breadth of treatment are essentially English, and at the same time are saved from the superficiality too common in native technical treatises, by the industry and original ability of the energetic American. At the same time, the present work is not devoid of a certain diffuseness, which we think is referable to the author's enthusiasm leading him into disquisitions too long for the proper purpose of the book, but which is possibly the more marked to us because he is writing about American waters in particular, and about conditions not known in England.

The title may seem to many to claim too much; for Mr. Whipple puts aside at the outset all that relates to bacteria, and takes a very wide view of "drinking-water." He regards the subject of the examination of water as divisible into

(1) Physical examination.
(2) Biological examination.
  (1) Microscopical.
  (2) Bacteriological.
(3) Chemical examination.

A mode of classification which lands him in some inconsistencies—for some Schizomycetes are dealt with later on—and would vitiate the work if it were not clearly set forth that he is concerned solely with that part of the microscopical examination of water which is not bacteriological in the accepted sense of the word, and comes under the head of Limnology, dealing with those organisms which can be filtered out by means of fine-meshed nets or coarse filters incapable of keeping back water-bacteria.

The position reminds us of Miss Kingsley's diatribe against the utility of filters in West Africa.

"A good filter is a very fine thing for clearing drinking water of hippopotami, crocodiles, water snakes, cat-fish, &c. . . . ; but if you think it is going to stop back the microbe of marsh-fever — my good sir, you are mistaken."

Mr. Whipple, however, does not attempt to stop the smaller organisms by his filters, but only deals with the

larger ones, and having laid down his position, he proceeds to show, by his own interesting treatment of the theme, how large and important a subject that of limnology is, and how much neglected it has been in spite of the vast amount of information scattered in detail through the scientific literature of Europe.

Diatoms, Cyanophyceæ, Green Algæ, Fungi, and larger Schizomycetes, Protozoa, Rotifera, Crustacea, Polyzoa, Sponges, and miscellaneous higher aquatic plants and animals are dealt with in detail, and very interesting particulars are given of their numbers, distribution, and seasonal abundance in lakes and rivers, as well as many of their biological peculiarities.

Probably few people are aware that some of these small organisms contain powerfully odorous oils, and are responsible for the strong and unpleasant smell of certain waters, quite apart from decomposition.

We think, in spite of the many interesting facts regarding the existence of thermophilous organisms, the biology of blue-green algæ, &c., the author has missed some opportunities. For instance, we find no discussion or even mention of that puzzling phenomenon, the "Breaking of the Meres," although some of the organisms now known to be concerned—*Anabaena*, *Aphanozomenon*, &c. —are referred to. Again, it seems surprising that no reference occurs to the important *rôle* of such organisms as *Phormidium* in building up "Tufa," "Travertin," and other calcareous and siliceous substrata, particularly as some of the most striking examples occur in the United States.

Prof. Mason's little book proposes, if not protests, too much, as it is manifestly impossible for any author to cover the ground implied in the title in 126 small octavo pages of large print; and although we may give him credit for clear writing, an excellent selection of materials, and a general "up-to-date" style of presentment—including modern tables and charts—we cannot recommend this gossip about the chemical examination of water, with a smattering of bacteriological methods, as a serious text-book for students. On the other hand, we do commend it to the would-be writers of similar books in this country as indicating some of the new directions in which such writings should depart, and so abandon the too well-worn grooves in which our present bacteriologists are creeping onward.

Is not "Wolffhüggle," on p. 107, a misprint for Wolffhügel? It recurs on p. 108.

## HEART AND SCIENCE.

*Kritik der Wissenschaftlichen Erkenntniss.* By Dr. H. v. Schoeler. Pp. viii + 677. (Leipzig: W. Engelmann, 1898.)

A FRIEND of Dr. v. Schoeler's died a victim to his devotion to science, when too late he had reached the conviction that his jealous mistress was not worth the sacrifice he had made for her. What, then, asked v. Schoeler, are the data, what the results of science and philosophy? How shall we free ourselves from their obsession, and make them servants rather than tyrants? Is ethical nihilism the upshot and a pessimism subversive of human endeavour in all directions other than the intellectual? Has Nietzsche, after all, the right of it?

Dr. v. Schoeler answers these questions in the present volume at, perhaps, inordinate length, overloading his work with quotations and instances not always quite relevant to his point. He essays nothing short of a critique of philosophy and of the natural sciences and a constructive theory of life without assumptions. In this task his performance is necessarily very unequal in different sections. His chapter on the ancient philosophy, for instance, is a not very valuable contribution to the history of anticipations. Parmenides is a "Schelling of antiquity," but this does not prevent Heraclitus being called in as a forerunner of the *Identitäts-philosophie*, and the account of Aristotelian science goes little, if at all, beyond what can be learned from G. H. Lewes. On the other hand, where he is more at home and possesses a more living interest, our author's criticisms, if rambling, are often to the point. It is, however, not always quite easy to determine what is intended as mere exegesis, what is the expression of v. Schoeler's own view.

His philosophical sympathies lie on the whole with Kant, interpreted not as containing Idealism of the Hegelian type in germ, but as frankly realistic, relativist, even agnostic. His master is the Kant of the antinomies, and of the unknowable *Ding-an-sich*, treating "freedom" as an ideal amid phenomenal determination. He also has a word of praise for the doctrine of monads, leans a little to Schopenhauer, and accepts the results of evolutionist biology and psychology, though critical of the extent to which they solve ultimate problems, and prepared with Kant to admit the teleological judgment with the limited and relative range allowed it in the third critique. In the scientific field, his interests seem to be mainly what may be termed biological in the wider sense.

The smallness of the results of science in general, however frankly we may admit those results, and the little advance made by either philosophy or science towards the solution of ultimate problems, leads to a provisional relativism almost sceptical. But pure scepticism is negated by the facts of life, and if we reject mechanical constructions as dogmatic, and shrink on our spiritual side from the issue of all dogmatisms and positivisms, and, indeed, of all -isms, in the insanity of Nietzsche, we need to find an escape.

Such an escape, v. Schoeler holds, is not provided by religion. It must be sought for in the idea of humanity, and the furtherance of its ideals in art, in the ethics of family life, and in work in the cause of society. That this earth may or will be dissolved with its phantasmagoria of human knowledge, human passions, human needs, human ideals, lies perhaps not obscurely among the teachings of science. But this pessimism is not subversive of effort and aspiration, so long as it does not despair of the commonwealth. There is no absolute, neither god, nor world, that we can know in other than a relative sense or with other than a relative value, for they have no existence other than a relative one. The advance of the new outlook for the beginning of the twentieth century consists in freeing men from an illusion or a madness, in a new and undogmatic positivism or relativism without pride of intellect, and with a soun hold upon purely relative ideals through the æsthetic and the ethical emotions.

Intellectualism is the curse under which the author's friend fell, a martyr going at the last unwilling to his fate. To this we owe the degeneration held to be typically *fin de siècle*. We must meet the danger, exorcise the curse, by derogating from our claim to construe an absolute, and entering instead upon our heritage as men. "The Ideality of the life of feeling is the remedy."

Dr. v. Schoeler is undoubtedly fitted to write the history of philosophical and scientific ideas in certain fields. His chapter on matter, and his section on the achievement of nineteenth century surgery prove this. And his general power of appreciation and range of interest carry him a long way towards the adequate treatment of his encyclopædic task. But his rhetorical tendencies, shown, for example, in his interesting chapter on Nietzsche, and his exuberance, give the book an ineffectiveness which a smaller work might escape. And there is no index to a critique of all philosophy and all science, though laden on every page with citations !

H. W. B.

## *OUR BOOK SHELF.*

*Les Plantes Utiles du Sénégal—Plantes Indigènes—Plantes Exotiques*. Par Le R. P. A. Sébire. Pp. lxx + 341 (Paris : J. B. Baillière et Fils, 1899.)

RAPID strides have been made of late in opening up to commerce the several European possessions on the West Coast of Africa, and though much has already been done so far as vegetable products are concerned, only a small percentage of such products find their way regularly into European commerce, such, for instance, as palm oil, ground nuts, rubbers, chillies, and a few drugs, including kino, cinchona bark (introduced), strophanthus seeds, kola, &c.

With regard to timbers, there is a wide field for development, as there are many valuable woods in the forests that should find a ready market in Europe. African mahogany, afforded by *Khaya senegalensis* and other trees, is regularly imported into Europe, the trade in this timber having, during the last decade, increased enormously, and though it may lack the figure of Central American mahogany, it commands a ready sale in European ports. Taking into consideration all these facts, any contribution, however small, of the nature of the book under review must be accepted with thanks, so long as the facts and figures are trustworthy. In the preparation of the work the author's aim has been to provide those engaged in agricultural pursuits, or in the development of the vegetable economic resources of Senegal, with a manual of useful instruction. The book affords detailed information on indigenous plants, those that have become acclimatised, and further with those recommended for experimental cultivation.

The first forty pages deal with such subjects as the seasons, water supply, soils, injurious insects, &c., and is followed by a list of exotic economic plants cultivated in the country, with notes on the results obtained, the plants being classified according to their uses. Synoptical tables follow of generic and native names, together with a list of medicinal plants, arranged according to the diseases in the treatment of which they are employed. The main portion of the book, covering 300 pages, consists of a list of plants arranged under their respective natural orders, with scientific and native names and details bearing upon their properties, uses, and distribution. This portion of the work contains much valuable information, and bears evidence of zeal in its preparation. Besides dealing with indigenous and acclimatised plants, notes are given on various exotics and their uses with the view to their introduction into the Colony, or as an aid in determining the properties of indigenous plants upon the assumption that allied species in a given natural order possess similar properties. This is an excellent idea, and adds to the usefulness of the work. An index of Latin and French names, together with lists of native names, complete the work. In a book of this description, written on the spot, one naturally expects to find errors. The scientific names in many instances are obsolete or incorrectly spelled, and due care has not been exercised in the introduction or omission of capital letters, italics, &c. It would have been much better had the information been concentrated under fewer heads, and a good general index of scientific and native names combined would have added to the utility of the book. This may be remedied in another edition, but as the work now stands it can be recommended with confidence to those engaged in the development of the vegetable resources of Tropical Africa as a very useful addition to the limited number of such books already existing. Many illustrations of interesting subjects are intercalated in the text. J. M. HILLIER.

*Applied Geology*. By J. V. Elsden, B.Sc. (Lond.), F.G.S. Part II. Pp. vi + 250, with 186 Figures. (London : "The Quarry" Publishing Co., Ltd., 1899.)

THE first part of this work was noticed in NATURE, vol. lviii. (1898), p. 615. The second part consists of eleven chapters and an appendix. The first chapter (Chapter vi. of the work) deals in 19 pages with unstratified ore deposits. In the following chapter (vii.) the occurrence of the non-metalliferous minerals is described. We have, for example, $2\frac{1}{2}$ pages on coal, $1\frac{1}{2}$ on petroleum, and 1 on diamonds. As these pages include the illustrations, it is clear that the amount of information is completely out of proportion to the importance of the subject. No doubt the author would plead the lack of space for more, but surely in that case he should have made a judicious selection of the literature bearing on the subjects in question, and given full references to it. The same remark as to the almost complete absence of references applies to the book as a whole. Not only would such references have rendered useful short sketches of great subjects, which, standing alone, are almost useless, but they would have given the weight of authority for many statements which, unsupported, appear dogmatic. Chapter viii. is devoted chiefly to prospecting, developing, bed-mining, and vein-mining. The next four chapters deal with "Building and Ornamental Stones." They are chiefly illustrated by sixteen drawings of microscopic rock sections, clearly executed but without any indication of the amount of magnification. On. p. 76 the igneous rocks are classified into three groups—Plutonic, Intrusive and Volcanic ; but it by no means follows, as there stated, that intrusive rocks are microcrystalline, still less that volcanic rocks are necessarily partly or entirely glassy, nor is it logical to classify serpentine as intrusive, while peridotite, of which most serpentines are merely altered examples, is termed plutonic. Rocks used in the arts and manufactures are described in Chapter xiii. Engineering geology, especially the subjects of water-supply, embankments, tunnels and cuttings, occupies Chapters xiv. and xv., and the final chapter is devoted to surface features such as soils. In an appendix are given "simple rough methods for the determination of minerals and rocks," and there is a good index.

The work is very readable, well illustrated, and suited for geological students who wish to learn some of the applications of the science. The practical man will also gain useful hints, though he will feel rather at sea in reading some of the petrographical descriptions, and will wish for more details or references on many practical points.

*On Buds and Stipules.* By the Right Hon. Sir John Lubbock, Bart., M.P., F.R.S., D.C.L., LL.D. With four coloured plates, and 340 figures in the text. Pp. xix + 239. (London: Kegan Paul, Trench, Trübner, and Co., Ltd., 1899.)

THE new volume of the "International Scientific Series" forms a welcome addition to those already published, and it will be read with interest by all who are drawn to a study of the natural history of plants. For although accounts of bud-protection, &c., are to be found scattered through various journals, there existed no connected story of the numberless artifices by which plants shield their winter buds before the appearance of Sir John Lubbock's book. Naturally much of its contents includes matter of common knowledge to those botanists who care for the study of the living plant, but even for them there is much which will be probably found to be novel, and at any rate well worth reading; whilst the freshness and first-hand character of the recorded observations affords a pleasure which those who are acquainted with the author's previous essays in natural history will naturally expect to enjoy from a perusal of the work. It is refreshing to observe that Sir John has not allowed himself to be trammelled too much by orthodoxy—to find that, for example, he declares for the stipular nature of the outgrowths on the petioles of the early leaves of the flowering currant. In the account of the stipules in the genus *Tropaeolum*, however, there seems to be no mention of the interesting fact that the first two leaves (following on the cotyledons) in the common "nasturtium" are stipulate, whereas these structures are absent from the later developed leaves. Indeed, the whole genus seems worth a more extended treatment from the point of view of stipulation, affording, as it does, almost all transitions from complete development to a complete arrest of stipular formation, and these facts are of especial interest in view of the stipulate character of allied forms.

The tendrils of sarsaparilla and also the ligule of grass leaves are considered, and probably with justice (at least as regards the former), as of stipular nature.

The beautiful arrangements by which buds are protected by means of developments of the axillant leaf, as in the plane, maple, *Rhus*, *Kalmia*, &c., are described and well figured; indeed, the excellence of the numerous drawings forms by no means the least welcome feature of the book. Space forbids us to do more than thus briefly indicate a few of the points contained in the volume, which is a most valuable contribution to the literature of a fascinating subject. J. B. F.

*The Philippines and Round About.* By Major G. J. Younghusband. Pp. xiv + 230. (London: Macmillan and Co., Ltd., 1899.)

IN this amusing and well-written book the author gives a very good description of the towns of Iloilo and Manila. The volume is the result of a short visit made soon after the Spanish-American war, of which we get an excellent account. The life and customs of the inhabitants of the Philippines are well described, and the reader cannot fail to be surprised at the slow progress civilisation has made in those parts. This fault is due, without doubt, to the bad condition of the Government. The only outcome of centuries of authority is an absolute want of national discipline. The Filipinos, far from being down-trodden by all the oppression and cruelty they have endured, are lazy and insolent; but, perhaps, this is not altogether surprising seeing that no wholesome authority has been used.

The author has been more interested in incidents of travel than in the natural history of his surroundings. There seems to be little domestic comfort in hotels or houses, and we, who realise so well the value of scientific appliances, cannot fail to be forcibly struck with the descriptions of the primitive state of the sanitary arrangements of the towns.

The book is a valuable addition to works of travel, and will be found a useful guide when visiting the Philippines and their neighbourhood, for good descriptions of life in Java and in the town of Saigon are also given.

*The Slide Valve Simply Explained.* By W. J. Tennant, A.M.I.M.E. (London: Dawbarn and Ward, Ltd.)

THIS little pamphlet of sixty-five pages, forming volume No. 2 of the "Model Engineer Series," was originally intended to help the author's railway students towards the attainment of clear general notions upon the subject of the slide valve. The author conceived the idea of using on a base-board a rotary disc to represent a crank-shaft, together with the idea of obtaining concentric circular diagrams of results, by using a crank-arm marked on the disc as an index-finger, and recording on the base-board the beginnings and ends of the arcs swept out by the crank in the various distribution-periods.

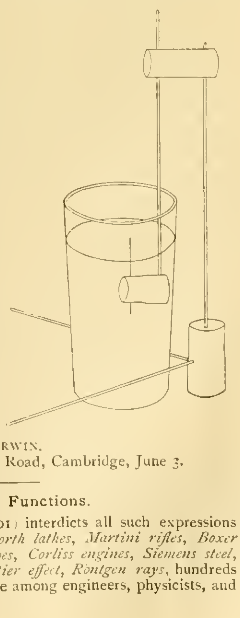
For students with little or no geometrical knowledge the book should be most useful. We think, however, that a student's time would be better employed in acquiring a sufficient amount of geometry to understand the Zeuner diagram, by aid of which the action of the slide valve can be represented more simply, quickly, and conveniently than by the author's disc diagrams. A. S.

## LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### Expansion of Solids by Heat.

THE following simple apparatus for showing the expansion of metals by heat may interest your readers. A cork rests on the table and is kept steady by two horizontal knitting-needles fixed into it. A third knitting-needle fixed in the cork stands in an upright position, and carries a second cork at its top. Another knitting-needle passes through this cork and projects vertically downwards into a glass of water, and carries a third cork at its lower end. This last cork carries a sewing-needle with its point projecting upwards just above the surface of the water. If one of the vertical knitting-needles is heated with a match, the point of the sewing-needle will disappear below the surface of the water; if the other is then heated, the point will appear again. These small movements can be easily seen by watching the reflection of a bright object in the surface of the water.



HORACE DARWIN.

The Orchard, Huntingdon Road, Cambridge, June 3.

### Bessel Functions.

So Mr. A. B. Basset (p. 101) interdicts all such expressions as *Armstrong guns*, *Whitworth lathes*, *Martini rifles*, *Boxer cartridges*, *Whitehead torpedoes*, *Corliss engines*, *Siemens steel*, *Thomson galvanometers*, *Peltier effect*, *Röntgen rays*, hundreds of which are in common use among engineers, physicists, and

mathematicians, to say nothing of the educated general public! His task is only comparable with the historic one which Mrs. Partington set herself with respect to the Atlantic.

Bangor, June 7. A. Gray.

### Larvæ from the Head of an Antelope.

In preserving the head of an old ♂ Hartebeeste (*A. cokei*), shot on March 31, I took from the nostrils a few hours after death some twenty large larvæ, which I am now forwarding you for identification.

On April 19 I found similar larvæ in the nostrils of an old ♀ Wildebeeste (*C. taurina*); but I think their occurrence in the heads of antelopes in this part of Africa must be comparatively rare; as, though I have shot and preserved the heads of quite a number—including many Hartebeeste—I have not come across them in any other instance. I may add, no appreciable emaciation was shown by the animals from whose heads the larvæ were taken. Richard Crawshay.

Kiu, Uganda Railway, British East Africa, April 29.

These larvæ are those of a fly of the family Oestridæ, and their structure, as well as their habits, shows them to be referable to the genus *Oestrus*, and to be allied to the well-known "Sheep-bot fly," or "Sheep-nostril fly" (*Oestrus ovis*).

Brauer in his "Monographie der Oestriden" (Vienna, 1863) mentions such larvæ as having been found in three species of antelope, and describes two species of fly (*O. variolosus*, Löw., and *O. clarkii*, Shuck.) from South Africa, both probably parasitic on antelopes.

Probably a search through the scattered literature since Brauer wrote would bring to light the record of other species of *Oestrus* with similar habits; but, unless the flies were bred from the larvæ, which would not be very difficult, the species concerned could not be identified.

Walter F. H. Blandford.

48 Wimpole Street, London, June 8.

### Walrus.

Ferdinando Verbesti (1630–1688), in his work in Chinese, "Kwan-yu-wai-ki" (Brit. Mus. copy, 15,297 *a*, 6, fol. 10, *a*), *sub.* "Marine Animals," relates thus: "The *Loh-sze-ma* is about 40 feet long, with short legs, and staying at the bottom of sea comes to the surface very seldom. Its skin is so hard that even swords are unable to pierce it. It has on its forehead horns resembling hooks, with which it hangs itself on a rock, thus sleeping a whole day without slightest awaking." With all deference to Prof. G. Schlegel, who takes the animal here described for the Narwhal (*T'oung Pao*, October 1894, p. 370), I will bolden myself for truth's sake to state that the walrus is meant herein, *Loh-sze-ma* being only a Chinese rendering of *Rosmar*, the Norwegian name of the walrus. The main parts of this description agree well with the description given by Olaus Magnus ("Historia de Gentibus Septentrionalibus," Rome, 1555, p. 757), but not exactly—*e.g.*, the latter author indicates the size of the animal by the words, "maximos ac grandis pisces elephantis magnitudine"; while the former gives it more precisely, though much more exaggerated.[1] Can you or any of your readers oblige me by telling from what very source Verbesti derived his description?

Magnus speaks of the sleeping of the walrus hanging itself on rock with its tusks to be often so sound as to expose its life to danger. Similar story is told in Japan of the sun-fish (*Orthagoriscus mola*), which is said to be floating asleep while its flesh and entrail are being removed (Kaibara, "Yamato Honzô," 1708, book xiii., fol. 43 *b*). Kumagusu Minakata.

7 Effie Road, Walham Green, S.W., June 5.

### Strawberry Cure for Gout.

In connection with the letter of "F. G." in Nature of June 8 (p. 125), on the strawberry cure of gout, I may mention that last year, when strawberries were so plentiful in England, a lady residing in Kent, who had formerly spent several years in Ceylon, where she had suffered from the wasting and often fatal complaint known as "Ceylon sore mouth" (the chief symptom of which is ulceration of the mucous membrane of the digestive organs), having had a return of the malady, and being unwilling to go abroad to undergo the "grape cure," conceived the happy idea to try strawberries instead, confining her diet to several pounds of these a day with plenty of milk. The remedy was so effectual that after a few weeks she was entirely cured of her malady, and had grown stout and well again.

5 Bedford Place, Croydon. Donald Ferguson.

[1] Gesner says: "Alium esse puto qui *Rusvaal* nominatur. quinquaginta passuum longitudine. . . ." ("Historia Animalum," lib. IV., *sub.* "De Rosmaro").

## THE FRESH-WATER PEARLS OF AMERICA.

The production of pearls by numerous species belonging to the fresh-water bivalve family *Unionidae* has been a matter of common knowledge from time immemorial. Such pearl-bearing mussels occur in the Tay, Isla, and several others of the rivers of the British islands, as well as in many of those of the continent, Mesopotamia, China, and North and South America. As a rule, however, such fresh-water pearls, in Europe at least, are inferior in lustre, and consequently in value, to those obtained from the pearl-oyster; and in those British rivers which produce the pearl-bearing species of *Unio*, it is stated that on the average one pearl is found in every hundred shells, and that only one pearl out of a hundred is fairly clear. During the eighteenth century, however, a considerable number of Irish pearls, ranging in value between 4*l.* and 10*l.*, were obtained, while one specimen, when mounted, realised 80*l.* In Scotland, pearls worth from 3*l.* to 4*l.* each are not unfrequently found, and it is stated that as much as 100*l.* has been paid for an unusually fine example. According to Dr. P. L. Simmonds, between the years 1761 and 1764 ten thousand pounds' worth of Scotch pearls were sent to London, while in the corresponding decade of the present century the amount was considerably more than double that value. During the dry season of 1862, when the lowness of the streams rendered the fishing unusually favourable, more pearls were collected than in any previous year; and the average price consequently fell to fifty shillings, or less. Twenty years ago, when from 5*l.* to 20*l.* was obtained for fine specimens, the general price was, however, much higher; and one Scotch pearl, for which forty guineas was given, is the property of the Queen.

British pearls were well known to the Romans, and it is probable that those from continental rivers were in demand at an equally early date. With the opening-up of the American continent by the Spanish explorers, the world was, however, flooded with a totally new supply of pearls, which there is good reason to believe were also of fresh-water origin. Wonderful are the accounts of the pearls found in the possession of the natives during the De Sota expedition from Florida to the Mississippi in 1540; and three centuries later Messrs. Squier and Davis disinterred vast quantities of damaged pearls from the ancient mounds of Ohio. So great was the number of pearls brought to light by these and other explorers, that it was considered improbable they could have been the products of the fresh-water unios of the country, and they were consequently believed to have been obtained from the pearl-oysters of the Pacific. In later years, however, many naturalists of repute were inclined to doubt the truth of this suggestion; and in an important and interesting memoir on the "Fresh-Water Pearls and Pearl-Fisheries of the United States," recently issued by the U.S. Fishery Commission, the author, Mr. G. F. Kunz, sums up the question as follows: "Notwithstanding the intercourse existing between remote Indian tribes, as shown by many authorities, and the fact that Pacific coast shells have been carried to Arizona, and that clam-shells have been found in Zuñi cities by Lieut. Cushing, it is likely that these pearls came, not from the pearl-oysters of the Pacific coast, but from the marine shells of the Atlantic coast and the fresh-water shells of the eastern part of the continent. It is very probable that the Indians opened the shells to secure the animal as an article of food; that the shells of some

varieties, such as the common clam and conch, were made into wampum; and that the pearls found in the shells were used as ornaments, whether lustreless pearls from the common oyster, or lustrous ones from the *Unio*."

The opinion that these old pearls are of fresh-water origin is based on the fact that many of the North American rivers and lakes still abound with pearl-yielding *Unionidae;* and it is, therefore, the more remarkable that for over two centuries from the date of the Spanish exploration nothing seems to have been ascertained about the latter. As Mr. Kunz says, "the natives have been dispersed, and the white race, occupied with other interests and necessities, took little note of the hosts of fresh-water shells inhabiting the streams and lakes, and did not suspect their power of producing pearls. In the year 1749, John Winthrop, in a natural history catalogue, first mentioned the production of pearls by the fresh-water mussels of the country. But more than a century was destined to elapse before any practical result arose from this knowledge; for it was not till 1857, when the "queen-pearl" was discovered at Notch Brook, near Paterson, New Jersey, that the country awoke to a conception of its hidden treasures. This pearl, which weighed 93 grains, was sold to the Empress Eugénie of France for 500*l*., and is said at the present day to be worth four times that sum.

Its discovery immediately gave rise to an outbreak of "pearl-fever"; and the mussels of Notch Brook and other rivers were gathered by the million and ruthlessly destroyed, frequently with no pecuniary profit. So careless indeed was the mode of operation that a pearl weighing 400 grains, which would probably have proved the record specimen of modern times, was ruined by boiling the mussel in which it was contained. During the first year of the fever, the value of the pearls sent to New York was fully 3000*l*.; in 1858 it fell to about 400*l*., while from 1860–63 the yield was only 300*l*. for the whole period. Although there was some slight revival of the trade in 1868, when pearls were discovered in the Little Miami river, Ohio, it was not till 1876 that any important find was made. But in that year 600*l*. worth were obtained from Waynesville, Ohio, a locality which has since yielded many more pearls, among them one of 38 grains weight, although of somewhat irregular shape. Since 1880 pearls have been found in districts further to the south and west; Kentucky, Tennessee, and Texas becoming the chief pearl-producing States, while Florida has also contributed its quota. New Brunswick and Canada likewise entered into the competition, while in 1889 Wisconsin appeared on the scene with a large consignment of magnificently coloured pearls. Within three months more than 2000*l*. worth of these latter reached New York, including one specimen valued at over 100*l*., the principal colours being purplish-red, copper-red, and deep pink. These finds led to intense activity among the pearl-hunters, with the result that the mussels were nearly exterminated in that district. Other parts of Wisconsin were found, however, to be equally prolific, and since 1889 it is estimated that pearls to the value of at least 5000*l*. have been obtained from that State alone. From exhaustion of the mussel-beds, the pearl excitement in the North-west subsided in the course of a few seasons.

In 1897, the "fever" burst out anew in Arkansas, where it extended west into Indian territory, and north into Missouri, Georgia and certain districts in Tennessee being likewise affected. This period of excitement and activity promised to extend into 1898, of which year no accounts are at present to hand. A remarkable feature about the Arkansas discovery was the fact that a large proportion of the best pearls were obtained lying loose on the mud of the shores, or at the bottom of shallow waters, while sometimes they were found in or upon the soil at some distance from the water. "This peculiar occurrence," writes Mr. Kunz, "is partly explained by the wide extension of the waters in flood times over the low regions of the State, and by the shifting of streams and isolation of 'cut-offs'; but the facts indicate further that under some circumstances, probably by agitation of floods and freshets, the loose pearls are lost or shaken out by the unios. A local impression prevails that the mussels 'shed' them at certain seasons. The fact that the pearls thus found were generally round and well-formed; the aggregation in repeated instances of several or many near or together, and the non-occurrence of shells with them at these places—all point to the washing out of loose pearls from the unios, and their distribution by floods and freshets."

In 1897, the excitement appears to have had somewhat disastrous results in certain districts by abstracting the washers from their regular fields of labour. It has also caused a revival of pearl-hunting in other districts, notably in the neighbourhood of New York. Florida may at present be regarded as an almost unworked country; but, judging from the specimens hitherto obtained, will probably yield a rich harvest. The two largest and finest pearls at present collected from this State weigh respectively 68 and 58 grains, and realised 170*l*. and 120*l*.

Connecticut has also witnessed a revival of pearl-hunting; and here one of the collectors has started the German plan of using a pair of pincers to prise open the valves of the shells.

The mussels that yield pearls in the States all belong to the typical genus *Unio*, and include at least sixteen species. Most pearls appear to be obtained from the common *U. complanatus*, which is a very thick and rounded shell, shaped not unlike a *Cyprina*. Pearls are, however, occasionally found in thin and elongated species, like *U. rectus*. In the Amazon basin of South America, the pearl-bearing species belong to the allied genera *Hyria* and *Castalia*, while in China the profitable species is a *Dipsas*, and is much like the ordinary British *Anodonta* in general form. *Unio* (*Margaritana*) *margaritifera* is the British pearl-mussel.

With regard to the occurrence of the Arkansas pearls on the mud, it may be explained that the *Unionidae* generally dwell in America on clear gravelly bottoms, and that in such situations the pearls when extruded from the shell would be ground up by the pebbles, or would be indistinguishable among them. Not so on the mud of the Arkansas streams, which seems to be the haunt of the unios. Whether the supposition above mentioned, that the pearls are washed out or shed from the shells during life, be well founded, requires further investigation. It is stated that their non-association with shells is due to their having been washed away by floods or freshets after expulsion from the living animal; but this explanation would apply with equal force to the pearls yielded by defunct mussels.

With a view of regulating the industry and preventing, if possible, the reckless destruction of mussels that takes place at each outbreak of the "fever," the U.S. Fish Commission commenced in 1894 an inquiry relating to pearl-fishing in the States; and the result of its labours up to 1898 is embodied in the report quoted above, the general conclusions being summed up as follows:—"The shells are most abundant in swift and clear waters, where the bottom is sandy or gravelly, and the country-rock calcareous. While still numerous in many streams, they have greatly diminished within a few years past, wherever the pearl-hunting enterprise has extended, and at some points are nearly exterminated. The pearls found are few, and those of marketable value represent the destruction of thousands of shells for every pearl obtained. . . . The methods of gathering the shells and extracting the pearls are the simplest and the most primitive, and the activity of a few

seasons generally exhausts the beds. This state of affairs is one that loudly calls for reform. The wealth of unios that fills our rivers and streams is rapidly being destroyed by ignorant and wasteful methods of pearl-hunting; and either some form of protection is important, or, if that be not possible, a wide diffusion of information as to better methods, and particularly the introduction of the tools used in Germany for opening unios far enough to see if there are pearls contained, without destroying the animal, which may then be returned to the water."

In the clearer streams of the country, the best method of collecting the mussels is by wading into the water armed with a water-telescope and a pair of spring nippers affixed to the end of a stick. The water-telescope consists of a long, light, quadrangular tube open above, and shaped to fit the face (to which it is strapped), and closed below with a glass plate. Dressed in waterproof clothing, the pearl-hunter wades along the bed of the stream in a stooping posture, with the lower end of the tube immersed in the water, by which he is enabled to see the mussels on the bottom, and so to pick them out one by one with his nippers. Fresh-water pearls in general are remarkable for their variety of tints, and nowhere is the variation more marked than in those from Wisconsin. Although white is the most common, almost any colour, from pink, purple, or red, to gold, bronze, and black, may be met with; while even a peacock-blue pearl is on record. The golden and wine-coloured specimens are presumably from the beautiful *Unio dromas*, the only common species with a golden or yellow interior to the shell. Pink appears to be the colour most highly esteemed in America, next to which comes red, and then black; but exceptional colours, like sky-blue, command exceptional prices. So far as shape is concerned, the first place is taken by spherical pearls, after which come hemispherical, or bullet-shaped examples, while oval or pear-shaped specimens follow. As regards the maximum prices obtained for American pearls, the statements are somewhat conflicting and indefinite. It seems, however, to be certain that a spherical pink pearl from Tennessee realised 130*l*., while a sky-blue pearl from Caney Fork, in the same State, was sold in America for 190*l*., and subsequently in London for 660*l*. With good luck, there is therefore evidently money to be made by pearl-hunting in the American rivers.

R. L.

## THE GEOLOGY OF MONT BLANC.[1]

MONT BLANC and its aiguilles present some difficult problems to both petrologists and physical geologists; problems, which, though they have something in common, are to a great extent distinct. The authors, however, have grappled with both. Their monograph, as a study of the petrography of the region, is full of valuable information; but we think they have not been quite so successful in dealing with what it is now the fashion to call the tectonics. This portion no doubt contains much that is valuable, but the physical structure of the *massif* of Mont Blanc has been treated too much as if the latter were isolated instead of being, as is really the case, inseparable from the western and central part, perhaps even from the whole, of the Alpine chain.

As most people are aware, the crystalline *massif* of Mont Blanc is defined by two well-marked troughs, occupied by rocks of secondary age, the more northern being furrowed by the valley of Chamonix, the more southern by that of Courmayeur. Each is bounded on the further side from Mont Blanc by crystalline rock, the former by the well-defined range of the Brevent and the Aiguilles Rouges, the latter by one or more varied character, and, generally speaking, of more bedded aspect.

FIG. 1.—Contact of protogine with crystalline schist below the Aiguille du Midi. P, protogine; S, crystalline schists; C, contact.

Of these two marginal crystalline zones, the northern is prolonged to the valley of the Rhone, where it crosses just below Martigny, after which it disappears beneath the sedimentaries of the Western Oberland. The southern passes on to join the Pennine chain to the east of Mont Blanc. The crystalline rock, however, which forms this and the rest of the central *massif*, is more or less fusiform in outline. (The term "amygdaloidal" applied by the authors seems misleading, as its connection with this structure is about equal to that of Monmouth and Macedon.) The central part of the *massif*—though according to them not the very highest rocks of Mont Blanc—consists of a granitoid rock called protogine, formerly said to be composed of quartz, felspar, and talc, and to be the most ancient in the region. The talc is only biotite, more or less hydrous, and the rock intrusive

[1] Recherches Géologiques et Pétrographiques sur le Massif du Mont-Blanc. Par Louis Duparc et Ludovic Mrazec. (Mem. de la Société de Physique et d'Histoire naturelle de Genève.) Tome xxxiii. Ptie 1re.

in the flanking crystallines. Profs. Duparc and Mrazec give an excellent account of the protogine; its microscopic structure and its chemical composition. It is a granite, varying from moderately coarse to slightly porphyritic, the silica percentage occasionally falling rather below that of an average granite. Enclosures of a more basic rock are found in it, which the authors consider, no doubt rightly, to be included fragments of more ancient material and not segregations. The age of this protogine cannot be exactly determined, but in other parts of the Alps a porphyritic granite, occasionally very coarse, yet bearing some resemblance to it, can be seen cutting the truly metamorphic rocks, called by the writer the "upper schists," which apparently are the newest among the Alpine crystallines. The protogine is flanked on each side by a zone of mica schists and fine-grained gneisses, which accordingly must be older than it, and it includes occasional strips of schist. Of these, some may represent wedged-in fragments of the last-named zones, while others probably are dykes, modified by pressure. The affected by subsequent pressure. These are certainly later than the Carboniferous beds, and earlier than the lowest Lias, for they occur as pebbles in a conglomerate of that age. Hence these "porphyries," like similar outbursts in other parts of the Alps, probably represent Permian eruptions. The authors think them not impossibly connected with the vein granites, which would assign the latter also to about the same period.

In discussing the "tectonics," the authors give an excellent *résumé* of the facts, so far as the immediate district of Mont Blanc is concerned, pointing out that the fan structure, of which this mass is generally considered to be a type, is not by any means so simple or so well developed as is generally supposed. They consider the central part of the chain to be a vast synclinal with minor secondary flexures between primitive anticlinals to the north and the south. According to one of them, a section across the range exhibits no less than eight anticlinal bands with intervening synclinals. On this view, we cannot venture to express a definite opinion; we think, however

FIG. 2.—Contact of protogine with crystalline schists below the Aiguille du Midi, seen from the Montagne de la Côte. The schists are at the base of the Aiguille, and of a very dark colour.

whole *massif* is traversed, in some places thickly, with veins of a fine-grained granite, poor in mica (aplite).

The sedimentary rocks associated with the Mont Blanc *massif* belong to two distinct eras. One group occurs but locally; the other has a wide extension, and perhaps was deposited over the whole breadth of this region of the Alps from north to south. The former group belongs to the Carboniferous period. It consists of conglomerates, often coarse, grits, and dark muds (now slates); the latter group forms part of the great Alpine Mesozoic series. At the base, Trias is found; this, however, near the Mont Blanc *massif*, is either feebly represented or absent. It is probably followed everywhere by beds of Rhætic age, but these often cannot be separated from the Lias. In parts of the Alps the series passes gradually upwards into the Eocene; in this district, however, nothing later than some portion of the Jurassic system is preserved. Here and there masses of "porphyry" occur (one with, some without, free quartz), often much that at present a suspense of judgment would be prudent. But that the structure is far less simple than it was formerly represented to be can hardly be doubted. That great complications exist is not surprising, for the region, like the rest of the Alps, has been repeatedly folded. The authors recognise the following as the principal movements: (1) The Caledonian folding, during which the injection of the protogine occurred. This, we presume, so far as it can be dated, would be earlier Palæozoic, perhaps post-Ordovician. Then came the Hercynian folding, which is supposed to have occurred in early Permian times, and to be connected with the ejection of the "porphyries." The axis of this folding ran slightly north of east. During the Mesozoic times, a subsidence continued, the mountains gradually disappearing, while deposition went on steadily.

Then came the Tertiary movements, by which the present chain was formed. We cannot attempt to discuss this part of the subject, for it is a complicated one

and the structure of the chain for a considerable distance to the south and the east must be taken into consideration. That great earth movements had preceded the Carboniferous period, and that mountains of a sort existed during it, and that this period was followed by very acute folding, are certain. We think, however, that the folds in this part of Europe (for reasons which have been published elsewhere) ran approximately from N.N.E. to S.S.W. Evidence of this may indeed be found in the district of which the authors are writing. Such flexures may have been the cause of the frequent trend of outcropping masses along almost the whole of the Alpine chain. During the Triassic period, as has often been observed, highlands, if not mountains, must have existed over more than one large area on the present site of the Alps, which afterwards disappeared beneath a wide-spreading sea. Then came the great Tertiary movements which formed the present chain. The authors apparently treat these as one, but most geologists hold that there were two epochs of maximum disturbance separated by one of comparative rest. The "building" of the present *massif* and the neighbouring mountains should have been treated, we think, in greater detail; for there is more than one interesting problem connected with the courses of the main streams, the positions of watersheds, and the localities chiefly affected by the different movements, which are practically unnoticed. Still the memoir, as a whole, is a very valuable contribution to our knowledge of Alpine geology.

T. G. BONNEY.

## THE BERLIN TUBERCULOSIS CONGRESS (1899).[1]

### II.

(*Section IV. Therapeutics. Section V. Sanatorium Treatment.*)

THE fact that 2000 doctors met together and discussed for two days the treatment, using this term in its broadest sense, of phthisis will, to the observant layman, be of evil omen. When a number of remedies or methods of cure for one disease are all guaranteed by their advocates as being efficacious, the attitude that one at once adopts is one of scepticism. How many doctors would meet together to discuss the treatment of primary syphilis, a disease which can be cured, and how long would it take them to do so if they did? In a multitude of counsellors there may be wisdom, but in a multitude of treatments there is rarely a cure.

The subject-matter of this Section was very fittingly opened by a paper of Dr. Curschmann's (Leipzig) on the curability of phthisis. In the narrow anatomo-histological sense, phthisis is rarely if ever cured; in the clinical sense, however, we can often accurately speak of a cure as having taken place, since the local signs in the lungs not only become arrested, but a certain amount of repair takes place, and the attacked individual becomes practically normal. The majority of cases of cure, however, are relative. In these cases, the local disease, although not coming to an absolute standstill, is of such a nature as to allow of the general condition of the patient remaining good.

The congress listened with great attention to a paper read by Prof. Kobert, of Rostock, on the medical treatment of tuberculosis. The results formulated by the author were of especial value, since they were not confined to his own clinical experience at Görbersdorf, but were derived from a series of inquiries addressed by him to general practitioners and lung specialists throughout Europe—200 in number. These specialists and practitioners had treated during 1898, the year to which the inquiry related, 50,000 cases of tuberculosis. The most interesting of these results are as follows: (1) that we have in our possession no drug which exerts what may be termed a specific action in tuberculosis; (2) that the early stages of phthisis can sometimes be met and cured without medicine of any kind; (3) in acute cases of phthisis, the fatal termination is neither avoided nor appreciably hindered by any kind of medicinal treatment; (4) that in the majority of cases of consumption medicinal treatment along with hygienic treatment is of the greatest possible use in allaying and easing cough, keeping up nutrition, and exerting a controlling action on the tubercle bacillus and its products. Dr. Brieger (Berlin) read a paper upon the treatment of pulmonary tuberculosis by means of tuberculine and allied methods. The author regarded Koch's tuberculine as of distinct value in cases of pure pulmonary tuberculosis, asserting that in several cases an active tuberculous process had by its means been brought to a standstill.

A valuable communication upon the climatic treatment of phthisis was made by Sir Hermann Weber; but since this was reported at length in the *British Medical Journal*, no further mention will be made of it here. A paper of great interest was read by Dr. Dettweiler (Falkenstein), the subject being the hygienic, dietetic and sanatorium treatment of phthisis. Dr. Dettweiler, being the chief physician to one of the largest private sanatoria in Germany, spoke upon this subject out of the fulness of his experience. The author, after emphasising the fact that in phthisis we had to deal, not with a local condition, but a symptom complex, considered in how special a manner a sanatorium could meet the individual requirements of each case, and that by this means alone—viz., meeting every special want or symptom of the patient as it arose—could we hope to be successful in our treatment. It was not from open air, baths, exercise, alcohol, or feeding that we were to expect a "cure," but from the co-operation each day, according to the state of the patient, of all these means. Prof. Winternitz (Vienna) discussed the hydrotherapy of phthisis, and was followed on this subject by Dr. Carl Schütze. Dr. Hölscher (Mülheim) read an interesting paper on the treatment of phthisis by guiacol carbonate and creosotal. The author, after giving a short *résumé* of the results of the continued use of guiacol, emphasised the fact that this method must be used in conjunction with forced feeding, especially in so far as concerns proteids. The guiacol is eliminated in combination with sulphur, and the sulphur thus used can only result from the breaking down of proteid material; hence the importance of the strength of the patient being maintained by a plentiful supply of proteid material in the food. Dr. Cervello (Palermo) described his method of treatment, which consists in the inhalation of a formic aldehyde gaseous compound. Prof. Landerer gave the results he had obtained by the injection of cinamic acid (Zimmtsäure $C_6H_5—CH=CH—CO_2H$). This substance, according to Prof. Landerer, acts by causing an increased leucocytosis, especially in the regions affected by the tubercular process. The action of many other antiseptics in tuberculosis was also considered, including iodoform and glycerine (Dr. R. Hammerschlag) and Izal (Dr. Tunnicliffe), a few preliminary observations with the latter drug tending to show that it acted, as would be expected from its composition, similarly to guiacol and creosote.

The serum treatment of tuberculosis was discussed by Prof. Maragliano (Genoa). This investigator's interesting researches in this field have already attracted considerable attention. The author, after having postulated from his own and Behring's researches the existence of tuberculous antitoxines and their presence in the blood of normal animals and man, stated that the quantity of these could be increased by injection. The injection of such antitoxines rendered animals partially or entirely immune to injections of tuberculous material, and lessened in man the reaction to tuberculine (Koch?). He further

[1] Concluded from p. 109.

affirmed that these "tuberculous antitoxines" had no poisonous action. Prof. Maragliano concluded by considering the harmful influence of pregnancy upon phthisis, and recommended it, when occurring in a phthisical person, to be terminated artificially. Many other interesting papers, for which we cannot find room here, were read in this section.

*Section V.—Sanatorium Treatment.*—Since this tuberculosis congress was the first of its kind, it is difficult, if not incorrect, to speak of any part of it as being a novel feature, but the relative newness of the sanatorium treatment of consumption rendered this Section the most interesting one of the whole congress. As these notes are intended for lay as well as professional readers, perhaps it would not be waste of time and space to discuss what is meant by the sanatorium treatment. It seems to the writer that all that is meant by sanatorium treatment is the placing of patients suffering from phthisis in its different stages in an institution or house where they can be constantly watched by skilled doctors, and where every appliance for rest and exercise and amusement in pure and dry open air, forced feeding ("ubernährung"), and hydrotherapy exist. So much has been said about open-air treatment, Nordrach treatment, and so on, that the more general one's remarks are here the better. If a personal name is to be attached to sanatorium treatment it ought to be that of Brehmer, whose book still remains the classic and, indeed, to all intents and purposes the only book upon the subject. If it is wished to label this treatment with the name of a place, it ought to be called the Görbersdorf treatment, for there in Upper Silesia Brehmer founded his institution, and there it thrives to-day. It must always be remembered that open air is, although an important part, only a part of the whole, insistance upon the food question, and proper and suitable medicines, including alcohol, and above all, the adaptation of all these means to the daily and even hourly fluctuations of the patient, are essential factors in the sanatorium treatment.

The subject matter of the Section was introduced by a paper of Prof. Leyden's, who sketched the development of the sanatorium question. Herr Schmieden (Berlin) read a paper upon the building and arrangement of sanatoria. Dr. Schultzer (Berlin) discussed the arrangement, management and results of sanatorium treatment. The author reckoned the cost of a sanatorium for 120 beds at 3*s.* per diem per patient. He pointed out that the results obtainable from treatment could be greatly improved by the construction of intermediate sanatoria, to which patients almost cured could go and get occupation while being still, to some extent, under treatment. Dr. Edward Kaurin gave an interesting account of the sanatoria for tuberculous patients in Norway. The largest sanatorium is situated on the sea coast, and apparently great attention is paid to diet, for each patient consumes more than two quarts of milk per diem, and about three ounces of butter, in addition to his ordinary meals. The cost per head is 1·20 kronen. Prof. Ewald treated the subject of sanatoria for children. Dr. Rufenacht Walters read a paper on the hygienic dietetic treatment of phthisis in Great Britain. The author emphasised the fact that open-air treatment, combined with increased diet, had long been practised in this country with success. He described shortly the hospitals, convalescent homes, &c., where this treatment had been followed. He pointed out the importance of the modern movement in this country for systematising the struggle against tuberculosis, and concluded with a few pregnant remarks concerning climate in the treatment of tuberculosis, and the necessity for improving the general mode of life of tuberculous patients. Dr. Sinclair Coghill made a communication upon the treatment of phthisis, in which he described the National Hospital for Consumption at Ventnor and the methods practised there.

Many other papers followed in this Section, giving the results at sanatoria situated in the most varied regions, and also discussing the difficulties to be met with and overcome in each country in impressing the hygienic treatment of tuberculosis upon the populace in general. National prejudice and customs, to some extent, perhaps, masked in robust health by the voluntary control of the individual, come very obviously to the surface in disease. The German, disciplined from the cradle to the grave, finds it much less hard to submit to the strict *régime* of the sanatorium than the Englishman, in whose eyes, perhaps, the advantages of individual liberty are somewhat over-estimated.

In these notes, filled with the business of the congress, no space is available even to enumerate its pleasures; suffice it to say that the congressists found ample recreation provided for them by the respective authorities in the evening, and returned refreshed by it to their somewhat depressing subject-matter in the morning.

F. W. TUNNICLIFFE.

## NOTES.

THE award of the sixth De Morgan medal was made by the Council of the London Mathematical Society on Thursday last, June 8. The medallist is Prof. W. Burnside, F.R.S., and the ground of his selection was for his researches in mathematics, particularly in the theory of groups of finite order.

THE death is announced of Dr. L. A. Charpentier, Professor and Fellow of the Faculty of Medicine, Paris, and member of the Academy of Medicine.

THE German Imperial School for the study of tropical diseases, the establishment of which is due to the suggestion of Prof. Koch, is to be settled at Hamburg.

MR. W. MARTINDALE has been elected president of the Pharmacutical Society of Great Britain.

MR. STANDEN, Government Quinologist, Madras, has been deputed to visit Java to study the system of planting cinchona and manufacturing quinine there, and will therefore be absent for some months. It is proposed by the Madras Government to considerably extend the cinchona plantations on the Nilgiris, and a large area has recently been cleared close to the Pykara Falls.

MR. H. J. MACKINDER, reader in geography at the University of Oxford, has just left England in charge of an expedition, the object of which is to make a thorough study of Mount Kenia, in British East Africa.

AS already announced, the autumn meeting of the Iron and Steel Institute will be held at Manchester on August 15–18. The preliminary programme shows that numerous visits to engineering and other industrial establishments have been arranged. Receptions will be given by the Lord Mayor of Manchester and the Mayor of Salford. A detailed programme will be issued when the local arrangements are further advanced. This programme will contain a list of the papers that are expected to be read.

THE Société helvétique des Sciences naturelles will meet at Neuchâtel on July 31–August 2. On the first day, discourses will be delivered by the president, Prof. Maurice de Tribolet, Prof. Roux, Dr. C. E. Guillaume, and Dr. L. Wehrli. On the following day, the various sections will meet, and on August 2 there will be discourses by Prof. Schröter, Dr. Morin, and Prof. R. de Girard. A number of excursions have been arranged, and there is every promise of the meeting being a successful one. The secretary is Prof. Dr. Henri Rivier, Neuchâtel, Vieux-Châtel 11.

WE learn from the Allahabad *Pioneer Mail* that some important changes are being made in the Meteorological Department of the Government of India. These comprise the abolition of a number of observing stations which have not proved worth keeping up, and the substitution for them of others in more favourable localities. Of the latter, most important are stations which are to be established at Cherapunji and one or two other places in Assam, which will enable a more careful watch to be kept over the meteorology of the tea districts, also regarding the periodical rise and fall of the rivers which are so important for the jute trade. Arrangements are also being made, but are not yet concluded, for the establishment of an observatory on Dodabatta Peak, the highest point in the Nilgiris, which is likely to be valuable in connection with the warnings of the monsoon.

THE preliminary programme of the eighteenth congress of the Sanitary Institute, to be held in Southampton, from August 29 to September 2, has now been issued. The president of the congress is Mr. W. H. Preece, K.C.B., F.R.S. Mr. Malcolm Morris will deliver the lecture to the congress, and Bailie J. Dick, chairman of the Health Committee, Glasgow, will deliver the popular lecture. Excursions to places of interest in connection with sanitation will be arranged for those attending the congress. A conversazione will be given by the Mayor (Councillor G. A. E. Hussey). The congress will include three general addresses and lectures. Three sections will meet for two days each, and deal with (1) sanitary science and preventive medicine, presided over by Sir Joseph Ewart; (2) engineering and architecture, presided over by Mr. James Lemon; (3) physics, chemistry and biology, presided over by Prof. Percy F. Frankland, F.R.S. There will also be eight special conferences.

A PARLIAMENTARY paper has just been issued showing the number of experiments performed on living animals during 1898, under licences granted under the Act 39 and 40 Vict., c. 77, distinguishing painless from painful experiments. Nearly all the experiments made under the certificate which dispenses with the obligation to kill the animal before recovering from anæsthesia, have been inoculations made (under anæsthetics upon rodents) with the object of diagnosing rabies. During the past three years, the number of experiments other than those of the nature of inoculations, hypodermic injections or similar proceedings has shown little variation (1516, 1462, 1511), while those of that character have increased (5984, 7360, 7640). Many of these latter experiments are performed in the course of professional duty for the diagnosis of disease, the preparation of antitoxins, the testing of water, and so forth. During the past year 43,000 doses of diphtheria antitoxin have been issued from two institutions.

THE second biennial engineering conference, held at the Institution of Civil Engineers last week, was opened by the president, Mr. W. H. Preece, K.C.B., F.R.S. This conference was not an international one in the sense of that held at Chicago in 1893, or of that which is contemplated in the year 1901 in Glasgow, in connection with the exhibition to be held there, but it may well be Imperial; and in furtherance of this idea the president suggested that, at the next conference, the Council should take measures to secure the presence of some members, delegated specially to represent engineering in parts of the British Empire beyond the seas. In the course of his address, the president remarked: "Science has followed, it has not led engineering. It is their intimate association which is the foundation of all industrial progress. The war of the microbes, the latest development of biology, is a consequence of sanitary requirements. Our knowledge of the diffusion of molecules and the solution of solids has sprung from the investigation into the mechanical properties and constitution of iron and its alloys, and the disturbances of the æther are becoming familiar through the practice of the so-called wireless telegraphy. Facts are derived from accident, observation or practice; laws are the result of research. Engineers have always appreciated science up to the hilt, but they wish that its special votaries were less dogmatic and more modest." Appreciative reference was made to the work of investigators like Newton, Faraday, Lord Kelvin, Lord Armstrong, Lord Lister and Lord Rayleigh; otherwise the remarks quoted would convey the impression that purely scientific investigations, such, for instance, as were made by Faraday, Clerk Maxwell, and Hertz, had followed instead of preceded advances in applied electricity.

THE U.S. Congress has shown appreciation of the valuable work accomplished by the Department of Agriculture by providing increased funds for many of the bureaus and divisions. We learn from the *Experiment Station Record* that the grant recently made by Act of Congress provides an increase of nearly 200,000 dollars over last year, and of more than half a million dollars over the year previous, the total appropriation for the closing fiscal year of the century being 3,726,022 dollars. This includes 720,000 dollars for the agricultural experiment stations in forty-eight States and territories, and a special grant for the establishment and maintenance of experiment stations in Alaska. The largest increases in appropriation are for the Weather Bureau and the Bureau of Animal Industry. The total grant for the Weather Bureau is 1,022,482 dollars, which includes an increase of 60,000 dollars for the maintenance of the new stations in the West Indies and adjacent coast, and 25,000 dollars for the erection of an addition to the present buildings of the Bureau in Washington. The total appropriation for the Bureau of Animal Industry is 1,044,030 dollars. This includes 50,000 dollars additional for investigations and inspection, and 20,000 dollars "for the purchase and equipment of land in the vicinity of Washington for an experiment station for the study of the diseases affecting the domesticated animals." The fund for irrigation investigations has been increased to 35,000 dollars. A grant of 10,000 dollars has been made for tobacco investigations, including the mapping of tobacco soils; study of soils and conditions of growth in Cuba, Sumatra and other competing countries; investigations of the methods of curing, with particular reference to fermentation; and originating improved varieties by means of selection and breeding. The Division of Chemistry receives 34,000 dollars—an increase of 5300 dollars—2500 dollars of which is for the equipment of a new laboratory. These additional grants will materially strengthen the Department of Agriculture and extend its sphere of usefulness.

THE process of manufacturing mechanical wood pulp is described by Mr. W. A. Hare in a volume just received, containing papers read before the Engineering Society of the School of Practical Science, Toronto. Within the past two or three years there has been a marked impetus given to the pulp and paper industry in Canada. Wood pulp will, for many years to come, be used to supply the world's demand for a filler in the manufacture of paper, in many of the coarse grades of which it is the only constituent. It is not confined, however, to the manufacture of paper alone, but is made into many useful articles of daily service, the market for which is increasing rapidly. No country in the world is better adapted than Canada for the establishment and expansion of wood pulp manufactures; and a prosperous future may be anticipated for the industry.

THE report of Mr. W. E. Plummer, Director of the Liverpool Observatory, upon the observations made during 1898, has been issued by the Mersey Docks and Harbour Board.

The results of astronomical and meteorological observations are recorded, and mention is made of the latest addition to the equipment of the observatory—namely, a seismograph, which has been placed in the basement, upon the solid rock which forms the foundation of the observatory. The instrument recorded a disturbance on September 17, 1898, probably having its origin in an earthquake near Tashkent, and it also registered movements produced by an earthquake at Port-au-Prince on December 29. Mr. Plummer hopes that during the year he will be able to trace the effects of tidal motion in the estuaries of the Dee and Mersey upon the seismograph in the observatory.

FROM an intemperate article in the *Journal of Indian Engineering* we learn of a regrettable state of feeling in Hong Kong concerning the comparative efficiencies of the Kowloon Observatory, of which Dr. Doberck is director, and the Jesuit Observatories of Manila and Zi-ka-wei. The Jesuit Fathers have long sent telegraphic messages connected with weather forecasts and storm warnings to the Spanish Consuls in Hong Kong, Shanghai and Singapore, who have forwarded the intelligence to the various newspaper offices in the respective districts, where they have been published for the benefit of the public at large. It is contended on behalf of the Jesuits that this voluntary service was of the greatest assistance to the mercantile marine and commerce of those ports: that the work was well organised and accurate and deserving of support and encouragement. But it is also alleged that the Secretary of War of the United States has peremptorily forbidden the despatch of these meteorological telegrams to any place outside the Philippines, and that this action has been put into operation on an appeal from Dr. Doberck. The charge uttered against Dr. Doberck is that he has used his influence with the U.S. Weather Bureau to move the Secretary of War (now the governing authority in Manila) to suppress the Jesuits' correct telegrams in order that his own forecasts may pass unchallenged. But surely the public can test the accuracy and value of weather forecasts, with or without any assistance from the Manila authorities. It is ill-judged policy to limit the distribution of any scientific information; and as in the present case the work is done voluntarily by the Jesuit Fathers, it is difficult to understand why the issue of the weather despatches has been forbidden.

DURING the last week of May, Mr. Walter Garstang, of the Marine Biological Association, carried out the second of his periodical surveys of the biological and physical conditions of the western region of the English Channel. The steam-tug *Stormcock* was again employed, and the same stations were visited as in February, viz., mid-Channel (50 fathoms), Ushant (60 fathoms), Parsons Bank, 50 miles W.N.W. from Ushant (75 fathoms), and Mounts Bay (45 fathoms). The distribution of temperature presented several noteworthy features. At the Ushant station, in spite of the depth of water, the temperature was found to be uniformly high from top to bottom; but at all other stations a surface layer of warm water overlay a deeper mass of cooler water. This warm surface layer was 7 fathoms deep in Mounts Bay, 10 to 15 fathoms deep in mid-Channel, and 15 to 20 fathoms deep over Parsons Bank. The temperature at 5 fathoms depth was 53°·0 F. in mid-Channel, 53°·2 in Mounts Bay, 54°·1 off Ushant, and 54°·5 at Parsons Bank. Rich collections of plankton were made at all stations in a variety of ways. The apparatus employed consisted of a surface tow-net, a fine vertical net after Hensen's pattern and a pump and 40 fathoms of hose for quantitative work, and a new form of opening and closing net for towing horizontally at any required depth. By means of this net many interesting features in the vertical distribution of plankton at the different stations were brought to light. Among the more interesting forms captured during the cruise may be mentioned the medusa *Hybocodon prolifer* (mid-Channel, and Mounts Bay, 40 fathoms), the siphonophore *Agalmopsis* (Parsons Bank, upper strata), the copepod *Isias clavipes* (Ushant, 3 fathoms), *Tornaria*, the larva of *Balanoglossus* (Parsons Bank, surface), and the eggs and larvæ of the pilchard (Ushant, 60 fathoms, and at the surface at all stations except Mounts Bay).

THE director of the National Observatory of Athens has published (1898) a first large quarto volume of its *Annals*, containing (1) an elaborate discussion of the meteorological observations made from 1839 to 1893, and (2) the detailed observations for the years 1894 and 1895; for the latter year, observations are given for every hour, and means are calculated for daily, ten-daily, monthly and yearly periods. The present observatory was regularly established in 1840, at the expense of Baron Sinas, and he also supplied it with the necessary instruments. The first director was Prof. G. Bouris, and the present director is Prof D. Eginitis. As now constituted, the observatory is divided into three sections: astronomy, meteorology and geodynamics, with a separate chief for each service, under the general superintendence of the director. From this long series of observations we note that the maximum temperature recorded was 105°·3, and the mean of the maxima 100°·2; the minimum was 19°·6, and the mean of the minima 29°·1. The average yearly rainfall (1858–94) was 16 inches; the driest month is July, and the wettest months November and December. The number of rainy days averages 99 in the year. In addition to the statements referring to observations made with instruments during the present century, the author gives, under each section, some interesting quotations relating to the ideas and observations of ancient Greek and Latin writers. Many characteristics of the climate of Greece are contained in almanacs dating from the fifth century B.C., and they are frequently found to confirm the results deduced from modern observations.

WE have received from Prof. H. Mohn, Director of the Norwegian Meteorological Service, a pamphlet on the employment of the boiling point thermometer in determining the pressure of the air and the correction for gravity. As recommended by recent meteorological conferences, the correction for gravity is now generally applied or quoted in meteorological tables. But the correction calculated according to formulæ differs more or less from that determined by actual pendulum experiments, and there are comparatively few meteorological stations where such experiments have been made. It is therefore important for meteorologists to find another means of determining this correction, and in the work in question Prof. Mohn publishes the results of experiments made at a number of land stations; and he shows that the correction for gravity may be very accurately determined by the improved thermometers used in conjunction with a mercurial barometer, the difference of the reduced readings being the correction required. It will be interesting to find whether the methods proposed could be employed at sea; at all events, a comparatively smooth sea would be necessary for the experiments.

AN "Annual Review of Physics," by M. Lucien Poincaré, is a valuable feature of the *Revue générale des Sciences* for May 30. It contains a summary of the chief discoveries made by physicists during the past year, classified under their various headings. Speaking of progress generally, it is pointed out that our knowledge of physics has not been revolutionised by any epoch-making discoveries like those of Röntgen and Zeeman, but that the year has been spent chiefly in extending and completing the knowledge of known phenomena.

THE latest researches on the propagation of malaria, by Prof. Grassi, in conjunction with Bignami and Bastianelli, show that all the species of the genus *Anopheles* hitherto observed by

the writers are capable of transmitting this disease. Experiments bearing on the hereditary transmission of the disease among the mosquitos themselves have hitherto led to negative results. Specimens of *Anopheles claviger* have been bred from parents taken in malarial houses, but no sporozooids have been observed in their salivary glands. Moreover, several observers have allowed themselves to be freely bitten by newly-bred mosquitos taken from malarial districts, but in no case have any ill effects been experienced. The present evidence tends to show that those *Anopheles* which have not bitten malarial patients are not infected, and are incapable of inoculating the disease; a single positive result would, however, disprove this conclusion.

MR. STEWART CULIN still continues his interesting comparative studies of games; and in the *Bulletin* No. 3 of the Free Museum of Science and Art, Philadelphia, 1898, he discusses the "platter" or dice of the American Indians, and finds that they originated from arrows and a throwing-stick used for divinatory purposes. He is of opinion that all the various forms of the game are not only derived, one from another, but that its place of origin may be definitely fixed in the country of the reed arrow and the *atlatl*, or throwing-stick; that is, in the arid region of the South-Western United States and Northern or Central Mexico.

VARIOUS items of Indian folk-lore will be found in the *Journal of the Asiatic Society of Bengal*, vol. lxvii. Çarat Candra Mitra writes on Bengali and Behari bird folk-lore and omen birds. The same author has a paper on coincidences between some Bengali nursery stories and South Indian folk-tales, in which he discusses the migration of folk-tales, and concludes as follows: "The similarity between the Bengali and South Indian versions of these tales can be accounted for only on the supposition that the aboriginal Bengali and Dravidian races assimilated the tales from Aryan settlers, the slight variations between the said two versions being due to the difference between the two borrowing races as regards manners, customs and language." Astronomical folk-lore is ṇarrated by Ramgharib Çhaube.

THE fourteenth fasciculus of the "North American Fauna," under the editorship of Dr. Merriam, is devoted to the biology of the Tres Marias Islands, the larger portion of the text being by Mr. E. W. Nelson. These islands, which lie off the west coast of Mexico, about sixty-five miles from the port of San Blas, have only recently been systematically explored by collectors. As might have been expected, this exploration clearly demonstrates their continental origin, their situation showing that at one period after their separation they formed a single larger island. The birds and mammals seem to have been more susceptible to modifying influences than has been the case with other groups, seven out of ten representatives of the latter, and twelve out of thirty-six of the former, being regarded as entitled to specific or sub-specific distinction.

MR. NELSON has likewise been devoting attention to the squirrels of the mainland of Mexico and Central America, the results of his investigations appearing in the May issue of the *Proc. Washington Academy*. It is concluded that the arboreal squirrels of North America should be divided, from the characters of the skull, aided sometimes by external peculiarities, into ten distinct sub-generic groups, four of which receive new names. The sub-genera are stated to occupy clearly defined geographical areas—a fact which speaks clearly as to their intrinsic importance; and it is further noticeable that the ranges of the most closely allied groups are invariably separated from one another by distinct gaps. Considerable importance as a group-character is attached to the presence or absence of the anterior upper premolar, and its relative size when developed.

IN his paper on "Mid-winter Surface and Deep Tow-nettings in the Irish Sea," recently published in the *Trans. Liverpool Biol. Soc.*, Mr. I. C. Thompson urges the importance of correlating the gatherings taken from upper and lower strata at the same time, much remaining to be learnt as to the effects of temperature and other influences upon the minute forms of marine life.

IN the *Bol. Mus. Paraense* for December last, the energetic director of the museum, Dr. E. Goeldi, laments the unsatisfactory state of our knowledge of the Brazilian fish-fauna, mentioning at the same time that although it is a subject to which his attention has long been directed, means and opportunity have been lacking. A commencement is, however, now made in the present synopsis of the fishes of Amazonia and the Guianas, which includes nearly forty pages of text, and a double coloured plate. The excellent execution of two of the figures in the latter, representing species recently described by Mr. Boulenger, is a very satisfactory feature.

THE April number of the *Agricultural Gazette of New South Wales* contains an illustrated account of a small ostrich-farm at South Head, where nine birds are kept. The methods of plucking and making-up the feathers are described and photographed. The annual product of each bird is worth from 10*l.* to 15*l.*; and the owner is of opinion that the industry is likely to prove a thriving one in the Colony. He considers that the birds, instead of being allowed to roam over large areas, as at the Cape, should be kept in small paddocks, and shifted from one to another of these at short intervals.

A PAPER by Mr. F. A. Lucas on the fossil bison of North America, published in the *Proc. U.S. Mus.*, vol. xxi., pp. 755-777, is specially noticeable for its wealth of illustration, having over twenty plates. The author, in opposition to some previous writers, is of opinion that all the bison skulls hitherto found in America are specifically distinct from the *Bos priscus* of Europe. No less than six extinct species are recognised; and while one of these is certainly a very distinct form, yet if all the others are valid species, it may be taken as certain that the fossil bison skulls of Europe would also permit of considerable specific division. One of the most important items in the paper is the determination that the so-called *Bos scaphoceras* of Cope, from Nicaragua, is not a bison at all, but a sheep. It seemed very strange that a representative of the former animals should have wandered so far south during the Pleistocene.

PERHAPS the most generally interesting article in the May number of the *American Naturalist* is one by Mr. Herrick, describing a case of the occurrence of a small hen's egg within one of ordinary size. Not that such abnormalities are uncommon—far from it. But the interest of the present case lies in the fact that the enclosed egg was situated in the yolk, instead of in the albumen of the larger specimen. In this respect it appears to be unique. The different types of such abnormalities are considered in detail. In ordinary cases, it seems that the small included egg represents a fragment of a normal ovum which has been ruptured, and has thus parted with some of its substance after leaving the ovary. Usually this fragment is treated in the oviduct like a full-sized egg and duly laid; but it may rarely be driven by antiperistaltic action up the tube so as to collide with the mother-egg, with which it fuses. From the general absence of yolks in such included small eggs, the ruptures that take place in the upper part of the oviduct must, as a rule, be confined to the albumen. Other explanations are given to account for double- or treble-yolked eggs.

IT is curious to note how the natural history of the fast-waning group of giant land tortoises is being gradually pieced

together from the evidences of living specimens transported far from their original habitat. An instance of this is afforded by Mr. E. R. Waite's description in the last issue of the *Records of the Australian Museum* of a male and female of *Testudo nigrita* recently living in the grounds of the Gladesville Hospital, near Sydney. The female, which died in 1896, was brought from the Galapagos in 1853, and the male, which has been acquired by Mr. Walter Rothschild, about 1866. Unfortunately, in neither case is there any evidence as to the particular island in the Galapagos group from which they were obtained, so that the exact habitat of the species still remains unknown.

SPECIAL interest is naturally felt at the present time in the geology of many of the islands in the Malay Archipelago, and therefore the summary just published by Dr. B. Kotô, Professor of Geology at Tōkyō, will be of service (*Journ. College of Science*, Imp. Univ. of Tōkyō, Japan, vol. xi. part 2). The author acknowledges his indebtedness to the labours of Prof. Suess; but he gives additional information, his object being to compare the structure and physical features of Taiwan with those of the Far Eastern Indies. Brief references are made to a great variety of strata and to the volcanic phenomena.

WE have received the summary report of the Geological Survey of Canada for 1898, in which the Director, Dr. G. M. Dawson, records the progress of the Survey, and quotes from the reports of the several officers on the staff "the more important results of their investigations, particularly such as may be of immediate value to the public from an economic standpoint." In northern Alberta some further experimental borings have been made in search of petroleum, and great trouble has been experienced in the effort to penetrate the "tar-sands" at the base of the Cretaceous strata, owing to "the clotting of the casing and tools with the heavy tarry petroleum, or maltha, mixed with sand, which was thrown up by the discharge of gas." The indications of oil-bearing strata have been proved over a large area, and it is hoped that the liquid petroleum may be found in the Devonian limestones which underlie the Cretaceous rocks.

MR. R. G. MCCONNELL and Mr. J. B. Tyrrell's report on the Klondike Region, Yukon District, is referred to in the publication mentioned in the foregoing note. The productive part of the Klondike gold-field, as at present known, covers an area of one thousand square miles. The gold occurs in the gravels flooring the bottom of the valleys, in stream-terraces lining the lower slopes of the valleys, and in a remarkable moraine or glacial deposit that occurs along the slopes of Eldorado and Bonanza creeks. The gold has been derived from the rocks of the immediate vicinity, and these consist of schists probably of Cambrian age. In various regions the want of good topographical surveys is a sad hindrance to the geological work, but that this is carried on in various portions of the vast territory of Canada with great energy and enthusiasm is evident from the details enumerated in this report of the Canadian Geological Survey. There are numerous observations on petrology, palæontology, and natural history generally. A large number of reptilian remains have been obtained from the Belly River formation in the Red Deer River district. The age of the formation, judged by the invertebrate fauna, is considered by Mr. Whiteaves to be the same as that of the Laramie (Cretaceous) series.

IN NATURE for January 19 we gave a brief account of the progress of the Maryland Geological Survey, which is under the direction of Prof. W. B. Clark, State Geologist. We have since received the second volume issued by the Survey, which embodies the full reports to which we previously alluded. As in the case of the first volume, it is beautifully printed and handsomely illustrated. The coloured plates picturing the macroscopic appearance of various granites and the Potomac marble are particularly good. There are, moreover, numerous pictorial views of quarries and of the physical features; there are excellent topographic and geological maps, and reproductions of some of the earlier topographic maps dating from 1527. The volume is mainly occupied (1) with an account of the building and decorative stones of Maryland, by Mr. G. P. Merrill and Mr. E. B. Mathews, by whom the physical, chemical, and economic properties of the stones, and their distribution, are very fully considered; and (2) by a report on the cartography of Maryland by Mr. H. Gannett and Mr. E. B. Mathews, who deal with the aims and objects of cartography, and with the maps and map-makers of Maryland.

MR. G. K. GILBERT describes a "Bowlder-Pavement" (to use the American spelling) at Wilson village, about twelve miles east of Niagara river, New York (*Journal of Geology*, Nov.-Dec. 1898). Such a pavement is formed when the boulders in till or boulder-clay are grouped in an approximately horizontal plane, and are striated on their upper surfaces in a common direction. The features are indicative of local glacial action which has affected a previously accumulated till, this action having removed a certain amount of material and caused the pressing down and striation of boulders along the plane of erosion.

IN treating of the glacial sculpture in Western New York (*Bull. Geol. Soc. America*, March), Mr. Gilbert shows how the broad plateau of Niagara limestone was but little modified, while its escarpment was rendered more prominent owing to the excavation by ice of the underlying shales which occupy the lowlands. Mr. Gilbert draws attention to a flexure produced by ice-action in the Medina shales at Thirty-mile Point, New York; and in a subsequent article he describes some giant ripple-marks in the Medina sandstones of New York, and these suggest that the formation was laid down in a large ocean whose waters were agitated by storm waves sixty feet high.

MR. G. CLARKE NUTTALL contributes to the current number of *The Contemporary Review* a popular account of the dependence of the flavour of tobacco upon the activity of bacteria during that important stage in the preparation of tobacco known as fermentation. Interesting reference is made to the work of Suchsland, who examined the germs which he found in the fermenting heaps of the finest West Indian tobacco. This German bacteriologist isolated and cultivated these bacteria, and then introduced some into quantities of inferior German tobacco, which was subsequently transformed so that connoisseurs could not distinguish it from the finest brands of tobacco.

WE have received from Messrs. Dulau and Co. a copious list of books and papers in British botany offered for sale.

COURSES of instruction in cryptogamic and cytological botany are given at the Marine Biological Laboratory, Woods Hole, Mass., during July and the early part of August.

HERR J. DORFLER, the compiler of the *Botanists' Directory*, proposes to publish a new edition about the commencement of the year 1900, and desires the co-operation of the botanists of all countries. His address is Barichgasse 36, Vienna IV.

A CIRCULAR has been issued inviting the attention of biologists to the biological station at Ambleteuse, in the Department of Pas-de-Calais, France. It has been erected very much on the plan of the American station at Wood's Hole, and is primarily designed as a summer school for biological students in connection with the Catholic University of Lille.

THE Reading College Agricultural Department has just issued its Fifth Annual Report on Field Experiments for 1898. The experiments were carried on with the co-operation of the Coun

Councils of Berkshire, Oxfordshire, Dorsetshire, and Hampshire, subsidies being granted by these bodies to the College to meet the expenses. The experiments were chiefly concerned with manuring and the rotation of crops, and furnished results which ought to be useful to farmers. Only one disease of cultivated crops, the "finger-and-toe," appears to have been attacked. Experiments on the cultivation of the sugar-beet in the neighbourhood of Reading gave good results. We notice that the staff of the College engaged on the field experimental work comprised two lecturers in agriculture, a lecturer in chemistry, an assistant chemist, a lecturer in geology and meteorology, and the director of the agricultural department, but no botanist or entomologist.

Many admirers of Tyndall's writings will be pleased to know that the volume entitled "Hours of Exercise in the Alps," which has been out of print for some years—the last edition (the third) having appeared so far back as 1873—has been reprinted. Many adventures in the Alps and elsewhere are narrated therein, and the volume has as much freshness and vigour now as ever it had. Messrs. Longmans, Green, and Co. are the publishers.

A new volume of the "Year-Book of the Scientific and Learned Societies of Great Britain and Ireland" has just been published by Messrs. Charles Griffin and Co. The volume contains, not only particulars as to officers, meetings, and membership of learned societies, but also lists of papers read before, or published by, every Society of importance throughout the kingdom during 1898. As a convenient work of reference, the volume only needs to be known to be used.

The current number of the *Photogram* contains as a supplement a very excellent reproduction of a snow scene, entitled "A Winter's Night," on special rough velox paper. The same number also contains the spectrum of iron and the solar comparison (on a slightly reduced scale), which has recently been obtained direct on a film thirty inches long at one exposure at the Solar Physics Observatory, South Kensington.

As Rugby was the first of the Public Schools to afford facilities for the study of science, we look to the Natural History Society of the School for a good report; and the one just issued is not disappointing. A prize essay, by Mr. P. H. Bahr, on "The Birds of Staffordshire and North Wales," is included in the report, together with reports on the work of various sections, and Mr. G. M. Seabroke's report on the observations made at the Temple Observatory in 1898.

The course of study in technical electricity, arranged by M. Eric Gerard for the Montefiore Electro-technical Institute of the University of Liége, formed the basis of a volume of "Leçons sur l'Electricité" written by M. Gerard, and published several years ago by MM. Gauthier Villars et Fils. The first volume of the sixth edition of this work has just been received. The subjects dealt with are the theory of electricity and magnetism, electro-magnetic induction, electrical measurements, thermo-electricity, dynamo-electric machines, transformers and alternating currents. Many changes have necessarily been made in order to include some of the more important inventions and discoveries of the past few years. The volume now runs into 819 pp., and is illustrated with 388 figures.

Many practical hints for photographers are given by Dr. E. Vogel in his "Taschenbuch der praktischen Photographie," the sixth revised and enlarged edition of which has just been published by the firm of Gustav Schmidt, Berlin. Among the additions to the volume is a description of the preparation of, and printing with, potassium bichromate paper (Gummidruck). Concise notes on the materials and methods available for the production of good negatives and various kinds of prints form a characteristic of this photographer's pocket-book.—Another photographic publication just published by the firm of Gustav Schmidt is a new part of the fourth edition of the late Dr. H. W. Vogel's "Handbuch der Photographie," edited by P. Hanneke. The subject of the new section is photographic printing by different kinds of processes.

"Picture Taking and Picturing Making" is the title of a neat and clearly printed little book of 115 pages, published by the Eastman Kodak Company. The object of this guide, as we may call it, is not to deluge the reader with theories and technicalities of photographic optics and formulæ, but to state clearly the main features regarding the production of good negatives, prints, and lantern slides. Parts of the book are somewhat familiar, in that they have appeared in the small Kodak manual; but the reader will find much that is new and useful. Needless to say, there are numerous and well-reproduced illustrations.

In the "Year-Book of Photography and Amateurs' Guide" the reader will find that the 650 pages of which it is composed contain a mine of information that should be of the greatest service to the photographer, whether he be amateur or professional. The five sections of the book, which bring before us progress and practice, being a collection of helpful articles by practical photographers, the tourists' companion and holiday guide from the photographic point of view, winter work, facts and formulæ, and, lastly, novelties of the year, contain useful and valuable information suitable for every one. Not less important is the collection of fine reproductions from negatives, on many different subjects, taken with several kinds of cameras and shutters, which lends an additional charm to this year's volume. The author has succeeded in presenting his readers with, not only an interesting volume to read, but one that should be at the side of every amateur for reference.

A second edition of "The Aborigines of Tasmania," by Mr. H. Ling Roth, has been published by Messrs. F. King and Sons, Halifax. In a supplementary note to the preface, Prof. E. B. Tylor points out that since the publication of the first edition, nine years ago, noteworthy progress has been made in the anthropological study of the Tasmanians. He adds, "That these rude savages remained within the present century representatives of the immensely ancient Palæolithic period, has become an admitted fact. . . . That the workmanship of the Tasmanians may be generally taken as below that of the Palæolithic Drift and Cave men, is apparent from the absence of any Tasmanian implement comparable to the symmetrical pointed picks worked on both sides, characteristic of the Mammoth Period in Europe." The additional information and figures referring to the position of the Tasmanians in the history of the human race make Mr. Ling Roth's volume of exceptional interest to students of anthropology.

The additions to the Zoological Society's Gardens during the past week include a Sooty Mangabey (*Cercocebus fuliginosus*, ♀) from West Africa, presented by Mr. G. Le Tantt; a Bonnet Monkey (*Macacus sinicus*, ♀) from India, presented by Mrs. C. Tarrant; two Slender Loris (*Loris gracilis*) from Ceylon, presented by Mr. Stanley S. Flower; a Leopard (*Felis pardus*, ♂) from Ceylon, presented by Mr. Edward Booth; a Black-backed Jackal (*Canis mesomelas*) from South Africa, presented by Mr. David D. Keith; a Two-spotted Paradoxure (*Nandinia binotata*) from West Africa, presented by Mr. Arthur Knights; a Vervet Monkey (*Cercopithecus lalandii*) from South Africa, presented by Mr. G. Marson; a Brown Gannet (*Sula leucogastra*) from Accra, presented by Miss Williams; a White-backed Piping Crow (*Gymnorhina leuconota*) from Australia, presented by Mr. G. T. Harris; two Common Vipers (*Vipera berus*) from Hampshire, presented by Mr. Chas.

C. Dallas; an Algerian Skink (*Eumeces algeriensis*) from North Africa, presented by Mr. R. H. Archer; a Rufescent Snake (*Leptodira hotambaeia*), a Hissing Sand Snake (*Psammophis sibilans*) from South Africa, presented by Mr. W. Champion; three Barbary Turtle Doves (*Turtur risorius*) from Africa, presented by Colonel E. J. Gardiner; three Blue-necked Cassowaries (*Casuarius intensus*) from New Guinea, a Senegal Parrot (*Paeocephalus senegalensis*) from West Africa, two Mute Swans (*Cygnus olor*, 2 ♂), European; an Echidna (*Echidna hystrix*) from New South Wales, deposited; a Hunting Crow (*Cissa venatoria*) from India, three Bar-tailed Godwits (*Limosa lapponica*), four Black-tailed Godwits (*Limosa aegocephala*), ten Green Lizards (*Lacerta viridis*), four Toads (*Bombinator bombinus*), European, purchased; a Japanese Deer (*Cervus sika*, ♂), an English Wild Cow (*Bos taurus*), two Squirrel-like Phalangers (*Petaurus sciureus*, 2 ♀), two Short-headed Phalangers (*Petaurus breviceps*, 2 ♂), a Patagonian Cavy (*Dolichotus patachonica*), a Crested Porcupine (*Hystrix cristata*), a Hybrid Lemur (between *Lemur macaco* and *Lemur brunneus*), born in the Gardens.

## OUR ASTRONOMICAL COLUMN.

Tempel's Comet (1873 II.)—Continued from *Astr. Nach.* (Bd. 149, No. 3554).

*Ephemeris for 12h. Paris Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ ″ | Br. |
|---|---|---|---|
| June 15 | 19 54 47·2 | 5 12 25 | |
| 16 | 56 11·5 | 5 22 24 | |
| 17 | 57 35·4 | 5 33 2 | 1·829 |
| 18 | 19 58 58·9 | 5 44 20 | |
| 19 | 20 0 21·9 | 5 56 19 | |
| 20 | 1 44·5 | 6 8 59 | |
| 21 | 3 6·7 | 6 22 21 | 2·048 |
| 22 | 4 28·5 | 6 36 27 | |
| 23 | 5 49·8 | 6 51 16 | |
| 24 | 7 10·7 | 7 6 49 | |
| 25 | 20 8 31·1 | 7 23 7 | 2·281 |

The comet is now more than four times as bright as when it was first re-observed by Prof. Perrine at Lick on May 6. Perihelion passage occurs on the 18th inst. During the period included in the above ephemeris the comet travels from the south-eastern part of Aquila to the north-west of Capricornus, being about 5° due north of $\alpha$ Capricorni on the 25th.

Return of Comet Holmes (1892 III.).—Continued from *Astr. Nach.* (Bd. 149, No. 3553).

*Ephemeris for 12h. Greenwich Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ ″ | Br. |
|---|---|---|---|
| June 15 | 1 22 38·3 | + 18 47 18 | 0·0341 |
| 17 | 22 56·5 | 19 23 22 | |
| 19 | 29 13·8 | 19 59 19 | |
| 21 | 32 29·9 | 20 35 8 | 0·0351 |
| 23 | 35 44·9 | 21 10 50 | |
| 25 | 38 58·8 | 21 46 25 | |
| 27 | 42 11·4 | 22 21 51 | 0·0362 |
| 29 | 1 45 22·7 | + 22 57 10 | |

During the above period the comet moves from near $\eta$ Piscium to about 2 degrees north of $\beta$ Arietis.

A telegram from Kiel, dated June 12, announces the first detection of this comet by Prof. Perrine at the Lick Observatory. The observation was made on June 10, at 15h. 2·2m. Lick Mean Time, the recorded position being

R.A. = 1h. 15m. 32s.
Decl. = + 17° 29′ 39″,

which will be seen to be fairly in agreement with the computed position. The comet is described as being very faint.

Comet 1899 *a* (Swift).—A circular from the Central Bureau at Kiel calls attention to the importance of the increase of brightness of this comet, which was recorded by several observers on June 4 last. Herr Kreutz has received a telegram from Herr Pokrowsky, of Dorpat, stating that communications received by him from Vienna, Bamburg and Hamburg, confirm the fact that on June 4 a decided brightening of this comet took place. The increase of magnitude was from 6 on June 2nd and 3rd to $5\frac{1}{3}$ on the 4th. A telegram also from Herr Hartwig gives further details. "The nucleus was of 9·5 magnitude, the total brightness being of magnitude 5. Greatest diameter of Coma about 9′; increase of brightness undoubted."

Another, from Herr Schorr, states: "Strong eccentric fixed star-like nucleus of 6·5 magnitude. Total brightness of comet 5 magnitude. Coma 9′ in diameter."

It will also be remembered that there was a decided increase in brightness of this comet from May 9 to 23, after which it gradually began to decline until the above sudden change was noted.

White Spot on Jupiter.—Herr Ph. Fauth, writing from a private observatory at Landstuhl to *Astr. Nach.* (Bd. 149, No. 3570), announces the observation on several occasions of a brilliant white spot on the north-eastern belt of the planet. The marking was observed to pass central meridian on May 8 at 11h. 25m., and on May 18 at 9h. 33m. It is about 4″ in diameter. The observations were made with a telescope of 7 inches aperture.

Two New Variable Stars.—M. Luizet, of the Lyons Observatory, announces in *Astr. Nach.* (Bd. 149, No. 3570) his observations leading to the discovery of two new variable stars in the constellations Vulpecula and Cygnus respectively.

The first is U Vulpeculae,

B.D. + 20°·4200. R.A. = 19h. 30m. 17·3s. } 1855·0.
Decl. = + 20° 0′·8. }

Four comparison stars were used and forty-three observations made during the period August 4 to December 26, 1898. These observations after reduction are plotted as the light curve, which is symmetrical and similar to that of $\zeta$ Geminorum. A maximum was found to fall on the date

1898 October, 21·61 Paris Mean Time,

and this in conjunction with a previously observed maximum by MM. Müller and Kempf,

1897 October, 2·4765 Paris Mean Time,

gives the period as

8·003 days.

The elements of the star U Vulpeculæ are therefore adopted as

1897 October, 2·4765 Paris M.T. + 8·003d. E.

The second variable is S U Cygni, the position being

B.D. + 28°·3460. R.A. = 19h. 39m. 1 0s. } 1855·0.
Decl. = + 28° 54′·9. }

Fifty-eight observations of this star were made from July 9 to December 26, 1898, and the results again plotted to give the light curve.

The period is determined to be

3·846d.,

and succeeding maxima may be calculated from the elements:

1897 October, 4·6665 Paris M.T. + 3·846d. E.

This star has a light curve showing an *irregular* decrease of brightness from maximum during about 2·7d., and a more regular increase during 1·1d., these features showing the variability to be somewhat analogous to that of $\delta$ Cephei.

## THE BORE AT MONCTON, BAY OF FUNDY.[1]

Moncton is situated on the Petitcodiac River, nineteen miles above the mouth of the Petitcodiac, where it enters the Bay of Fundy. This part of the river is more correctly an estuary which continues thirteen miles further up, as far as Salisbury Junction. At high tide the river at Moncton forms a sheet of water half a mile in width, while at low tide it consists of mud banks and flats, with a stream about 500 feet wide

[1] Abridged by Prof. G. H. Darwin from an advance copy of the Report for 1898 of the Tidal Department of the Survey of Canada, sent by Mr. W. Bell Dawson.

running with a strong current in a devious channel amongst the bars and mud flats, which are left dry at low water.

The run of the rising tide first breaks into a bore at Stony Creek, eight miles below Moncton, and it continues to the head of the estuary at Salisbury, thirteen miles above. The total distance on the river that a bore occurs is therefore twenty-one miles.

With regard to the time of arrival of the bore at Moncton, this really corresponds with the time of half tide. At the central moment between the previous and the following high water, which we may term the theoretical time of low water, the level of the water in the river is still falling; and it continues to fall, though at a much slower rate, for about three hours longer before the bore arrives. The time of the arrival of the bore is thus only about three hours before the next high water, which serves to account for the very rapid rise which takes place after the bore passes.

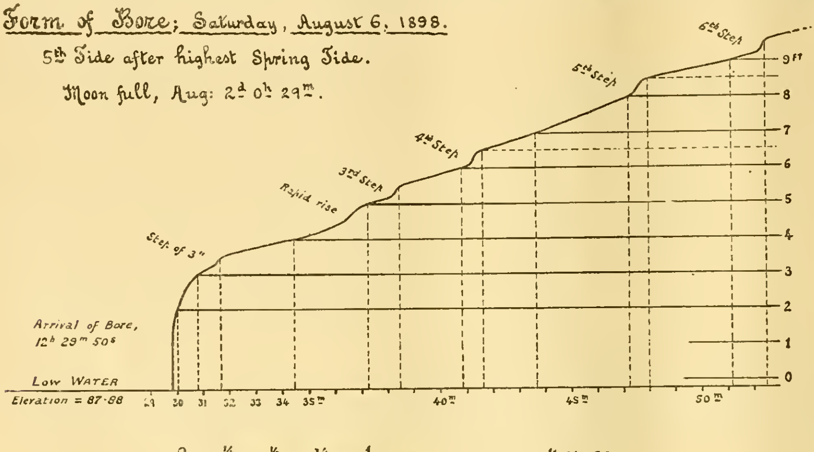
The rate at which the tide falls amounts at its maximum to eight feet per hour; but after the theoretical time of low water, the rate of fall soon becomes very slow, and the river appears to a casual observer to remain at the same level for some two hours before the arrival of the bore. The flow, however, continues to be fairly swift; and it no doubt still consists of tide water. The rate of fall in the level of the water, as measured shortly after spring tides, was found to be as follows:—

From $4\frac{1}{2}$ to $2\frac{1}{4}$ hours before arrival of bore, rate of fall *six inches* per hour.
,, $2\frac{1}{4}$ to 1 hour ,, ,, ,, ,, *four inches* ,,
,, 40m. to 15m. ,, ,, ,, ,, *three inches* ,,

The first observation of the bore was made on the evening of August 4. The point of view commanded some two or three miles down stream below the bend, as well as the foreshore opposite Moncton. The moon was a little past the full, and was well risen before the bore arrived; and the sky was then clear also. There was a very slight breeze, and in the stillness sounds could be distinctly heard. It was thus at the spring tides, and twenty-four hours after the lowest of the tides at that moon.

The first sound of the approaching bore was heard at 23h. 8m., in 60th meridian time, and two minutes later the sound was quite distinct. This sound was very similar to the noise of a distant train when heard across water. It afterwards increased to the usual hissing and rushing sound of broken water, as in a rapid on a river; but there was no mingling in this sound of any roar, such as a waterfall makes when falling into deep water, even from a moderate height. The bore arrived at the wharf at 23h. 19m., or eleven minutes after its sound was first heard. The rapidly-flowing layer of incoming tide advanced over the current of the river in the opposite direction, with a front of broken and foaming water, which had a height of perhaps two or three feet. The front edge was by no means straight. The higher part of the bore extended across the waterway, and this was bent back and also heightened in the middle by the opposing current of the river, which is naturally swiftest at the centre of the stream. Beyond this the bore formed a long sweep, where it broke over the flats, retarded and decreasing in height towards the further bank of the river.

The surface current of the water following the main front has the same speed of flow as its rate of advance; and after the main front passes, there usually follow a series of others, stepped up a few inches of additional height. These form irregular lines of curve across the surface of the advancing tide, which do not extend far without interruption. These may be due in part to back-wash from the flats into the main channel. As seen in the day-time, the water forming the bore is excessively muddy and reddish-yellow in colour, just as the outflowing water of the river also is. The actual broken water in the front is nearly white, except at the shore end; but the long edge of the advancing water on the flats appears nearly black in strong sunlight. With a stiff breeze down stream, the sound of the bore cannot be heard till it has approached within a few hundred yards.




CORRESPONDING SCALE OF DISTANCE FROM AVERAGE SPEED OF BORE.

AVERAGE SPEED AS OBSERVED = 8·47 MILES PER HOUR.

During the neap tides the bore still appears, and the front edge usually breaks a few inches high. But there are times when it consists merely of a heavy ripple, like the side waves from the bow of a steamer when they are advancing over still water; and it then only breaks occasionally, except in passing over the flats.

The rate of advance of the bore was timed from a point of observation on one of the upper wharves, which commands a view around the bend of the river. The velocity, as determined from several observations, was about $8\frac{1}{2}$ miles an hour.

To ascertain the form of the bore, and its rate of rise, a graduated board 13 feet high was set up in the front of the wharf, at which the tide gauge was placed. The current, after the bore passes, appears to have the same surface velocity as the rate of advance of the bore itself.

The height of the bore, as observed at spring and neap tides, and the rise of the water following it, are shown in the report by diagrams, of which one is reproduced here. The rise is by

no means uniform. There are at times distinct steps, which are sometimes visible as such, on the surface of the incoming water. At other times the water holds its level for a short interval, and then rises rapidly afterwards to make up, as it were, for lost time.

The diagram may also be taken to represent the form of the bore, or its profile along the river at any given moment. Strictly speaking, this involves the assumption that the whole mass of water moves forward at the same speed as the broken front which forms the bore itself; which in all probability is not very far from the truth. To assist this view, a scale of distances is given on the diagram, which is based upon the average rate of advance of the bore in running up the river.

The bore itself is clearly the broken water at the front edge of a long water-slope which advances up the river. The greatest rate of rise at spring tides after the bore has passed amounts to 3·00 feet in 10m. 5s.; and if we take for the average speed $8\frac{1}{2}$ miles per hour, the equivalent water-slope is 2·10 feet per mile. This slope appears very moderate in the circumstances, although it is really greater than in most rivers, except where rapids occur. Also, as a question of hydraulics, this slope would undoubtedly prove to be in correspondence with the speed of the currents following the bore, if the problem were fully worked out.

It is said that formerly the bore used to be higher than at present, owing to changes that have taken place in the bars in the river, which now obstruct the channel at low water and interfere with its development. No very definite information could be obtained as to this.

On August 22, 1892, a good photograph of the bore was obtained, which has been published in a report of the Geological Survey. Its height as then measured was 5 feet 4 inches. It is clear, from the observations, that in three to four minutes after the bore passes the water has already risen an extra foot. The greatest height which was measured in the above observations was 3 feet 3 inches, although it would be a little higher at the middle of the river. This may probably be taken as a fair average at ordinary spring tides. The maximum no doubt occurs when the moon is in perigee at full or change, and also at its maximum declination, as this gives the greatest difference in favour of one of the two tides in the day. Something also depends on the level to which low water falls, as this practically adds to the height of the bore. The total difference, however, in the level of low water between spring and neap tides, and between one set of spring tides and another, was found to be little more than one foot altogether, as observed in the summer season. Late in the autumn, when the fresh water outflow of the Petitcodiac is increased, the water surface at low tide does not fall so low.

The time of the arrival of the bore, with reference to the time of high water, was worked out from the observations obtained while the tide gauge was being erected. The time of high water at Moncton was obtained by difference of establishment, from the tide tables for St. John. The comparison shows that the time of arrival of the bore varies from 3h. 1m. to 3h. 34m. before the time of high water. This result may, however, be subject to revision.

It is hoped that the arrival of the bore, being a well-defined moment, may serve to throw light on the whole question of the progress of the tide in the Bay of Fundy.

The only other place in the Bay of Fundy at which the bore has been seen is in the upper part of Cobequid Bay. The tide there used to arrive as a bore at Maitland, at the mouth of the Shubenacadie River; but a change in the position of the sand bars below Maitland now prevents this. In running up the Shubenacadie, however, the tide still breaks occasionally into a ripple or miniature bore.

## *THE BOYLE LECTURE ON THE PERCEPTION OF MUSICAL TONE.*

ON Tuesday, June 6, Prof. McKendrick delivered in the Lecture Room of the New Museums, Oxford, the annual Boyle Lecture, the subject being the perception of musical tone. The lecture was entirely devoted to a consideration of the functions of the cochlea, the minute anatomy of which was fully described. The internal ear consists of a complicated series of sacs and tubes filled with fluid. In certain situations the walls of the sacs contain highly differentiated epithelial structures, which are intimately related to the terminal filaments of the auditory nerve. The problem is to explain how the pressures transmitted by the foot of the stapes affect these terminal structures in such a way as to excite sensations corresponding to the pitch, intensity, and quality of tone. The dimensions of the internal ear are so minute as to form only a small part of the wave-lengths, even of tones of high pitch. The nerve endings are still smaller, but they also act as minute portions of any wave, and any reasoning as to the effect of such waves is quite irrespective of the small dimensions of the receiving organs in the internal ear. If we consider a wave of sound as a series of states of condensation and states of rarefaction, travelling on continually in one direction; and, further, if we remember that the motion of each individual particle forming the wave is very small, and is alternately backwards and forwards, in the same line as that in which the wave travels, we see that the movements, inwards and outwards of the base of the stapes, correspond to these oscillations, or, in other words, to increase and diminution of pressure with each wave. Some of the possible movements of the base of the stapes were described, along with their action on the perilymph surrounding the utricle and saccule. We can hear musical tones and noises, we have a peculiar auditory sensation to which we give the name of beats, and we have the power of analysing a musical tone into its component parts. A demonstration was then given of the limits of pitch perception, of beats, and of beat tones. As regards the perception of intensity, the results of inquiries made by Töpler and Boltzmann, and more especially by Lord Rayleigh, showed the delicacy of the ear for sound, as regards energy, is about the same as that of the eye for light. The ear may be affected by vibrations of molecules of the air not more in amplitude than ·0004 mm., or 0·1 of the wave-length of green light; while Lord Rayleigh says "that the streams of energy required to influence the eye and ear are of the same order of magnitude." The question of analysis was next considered, and the bearing on it of Ohm's principle and Fourier's theorem, as regards wave-forms. The lecturer stated that on the whole he was not yet satisfied from any observations he had been able to make that the ear took cognisance of differences of phase, and he pointed out the peculiar difficulties in making observations on this point. He was still inclined to support the views of Helmholtz. Illustrations were given of wave-forms as revealed by the phonograph, and an instrument enabled the audience to hear experiments on pitch, intensity, and quality. Several violin records of rare beauty were reproduced. The lecturer next discussed the probable action of the cochlea. There are only three ways in which the ductus cochlearis, which contains the nerve-endings, may be affected. Either (1) small vibratile bodies may exist between the pressures sent into the organ and the filaments of the auditory nerve, each vibratile body having a frequency period of its own; or (2) individual nerve-fibres may be directly excited by waves of a definite period—that is to say, there may be differences in the nerve-fibres, so that they have a selective action; or (3) the organ may be affected as a whole, all the nerve-fibres being affected by any variations of pressures, and thus the power of analysis, which is admitted, is relegated from the peripheral to the cerebral organs. The first hypothesis seems most probable, for (1) the existence of such bodies would give a natural explanation of many, if not all, of the phenomena; (2) the evidence of comparative physiology points to a gradually increasing complexity in the structure of all the terminal organs of special sense, as there arose a necessity for differentiation and discrimination in the effects of various kinds of stimuli; and (3) investigations into the action of all the sense-organs, such as those of touch and temperature in the skin, of light and colour in the retina, of taste in the tongue, and of smell in the olfactory region—all indicate specialisation of function in the peripheral apparatus. The action of the cochlea was then fully described, and stress was laid on the movements of segments of the membrana basilaris causing contacts between the apices of the hair cells and the under-surface of the membrana tectoria. Suppose that, in accordance with the view of Helmholtz, a segment of the basilar membrane were thrown into sympathetic vibration, it would move in a direction at right angles to the direction of its fibres. These movements would be communicated to the structures lying on its upper surface, and if we suppose the arches of Corti to be elastic, such movements would be transmitted to the hair-cells. These would move in the line of their long axis; in other words, their hairs would move up and down in the meshes of the membrana

reticularis, and strike against the under surface of the membrana tectoria. A reaction would take place from the latter, and thus the delicate nerve-endings between the hair-cells would receive pressures corresponding in frequency to the oscillations of the membrana basilaris. In the cochlea of birds and amphibia, the mechanism is practically the same, but in consequence of the membrana basilaris not being highly differentiated, there cannot be the nice discrimination of pitch of tone which exists in the higher animals. The lecturer gave reasons for holding that a bird has a power of discriminating pitch only through a narrow range. These views were also, on the whole, supported by pathological observations in cases of deafness, and of the deafness of boiler-makers in particular. In the latter there is the loss of perception of high tones, and degenerations are observed in the lower whorl of the cochlea, as is required by theory. The action of the cochlea, as thus conceived, was demonstrated with a model. The lecturer also gave a large number of measurements of parts of the ear, showing that there were a sufficient number of structures in the cochlea to enable us to detect differences of the 1/64th of a semitone, thus amplifying the conclusions reached long ago by Helmholtz. The number of nerve-fibres in each cochlear division of the auditory nerve is about 14,000, giving something like 1250 for each octave through the eleven octaves of audibility. Assuming that the number of auditory filaments is the same for each of the eleven octaves (an unlikely supposition, as there will probably be a larger number of filaments for octaves in the middle of the range of the ear), there will still be two filaments for each 1/64th of a semitone; while, for the same interval, there will be three fibres of the membrana basilaris, and two hair-cells. The production of combination tones, differential and summational, was next considered, the lecturer stating that, in his opinion, and founded on experiment, both had an objective existence. They are not beats, but true sounds superadded to the generators, and thus they fall within the scope of Ohm's law. The theories, other than that of Helmholtz, were then criticised; namely, those of Rutherford, Waller, Hurst, and the more recent one of Max Mayer. The most obvious objection to any theory which dispenses with peripheral analysis is that it leaves the exceedingly elaborate structure of the organ of Corti, and indeed of the cochlea, as a whole, out of account; or, to put the matter in another light, it assigns to that organ a comparatively simple function. Ohm's law also may be subject to certain limitations, but there is no substitute for it. Max Mayer agrees with Hurst in imagining a series of waves transmitted along the scalæ, instead of the scalæ forming part of one wave. The two differ in respect that Max Mayer supposes, on physical grounds, that the amplitude must diminish from base to apex of the cochlea; while Hurst argues, also from the physical point of view, that the amplitude must increase. This is a serious discrepancy, inasmuch as Mayer's theory rests wholly on the supposition of diminished amplitude. It seems impossible to conceive of minute waves following each other in rapid succession in the minute tubes forming the scalæ. These theories are independent of the principle of sympathetic resonance, imperishably associated with the name of Helmholtz, and which still, in the lecturer's opinion, holds the field. Lastly, the lecturer pointed out that the roots of the auditory nerves were probably more widely distributed and had more extensive connections than those of any other nerve. The intricate connections of these nerves were only being unravelled. This pointed to an explanation of how music penetrates to the very roots of our being, influencing by associational paths, reflex mechanisms, both cerebral and somatic, so that there was scarcely a function of the body that might not be affected by the rhthymic pulsations, melodic progressions, and harmonic combinations of musical tones.

## THE DARMSTADT MUSEUM.

THROUGHOUT the civilised world attention is being concentrated on the improvements in the mode of arranging specimens in the exhibition galleries of natural history museums; so that they should be both attractive and instructive to the general public, and at the same time useful to the student. Nowhere does this advance seem more marked than at Darmstadt, where the Director, Dr. G. von Koch, has just published an interesting and well illustrated progress report ("Die Aufstellung der Tiere im neuen Museum zu Darmstadt," Leipsic, 1899.)

We gather from this report that a large proportion of the museum is devoted to the systematic classification of animals; and it is gratifying to observe that not only are skeletons and skulls ranged side by side with the mounted skins, but that anatomical preparations and remains of extinct forms are introduced in their proper serial position. A notable feature (in the seventh gallery) is the exhibition of a series of economic animal products, such as furs, wool, leather, ivory, tortoiseshell, mother-of-pearl, shell, coral, &c. But the greatest novelty is the formation of a gallery (the eighth in the series) illustrating the geographical distribution of animals on the globe. And here, instead of arranging the specimens on the conventional wooden stands on tier upon tier of shelves, an attempt has been made to reproduce the natural surroundings of their habitat.

To take, for example, the South and Central American region, we find, as shown by one of the plates accompanying the report, alligators, tapirs, carpinchos, chajas, &c., occupying the low land by the river. In the adjacent forest tract we have anteaters, sloths, coatis, pacas, opossums, armadillos and the characteristic monkeys. On a higher level we have the open pampas and llanos, with peccaries, brockets, pumas and rheas; while the background of the scene is formed by mountain peaks tenanted by guanacos, vicugnas and condors. Birds of other kinds are likewise introduced in appropriate positions so far as the limits of space permit. Similar scenes represent the other great zoo-geographical regions; and it is important to notice that the whole series is ushered in by the fauna of Hessen-Darmstadt itself.

It would undoubtedly add much to the interest and instructiveness of our own natural history museums if arrangements could be made for the formation of galleries of economic and distributional zoology on somewhat similar lines.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—A number of the foreign guests who had been present at the Stokes jubilee celebration and the Royal Institution centenary were invited to Oxford on the 8th, and were entertained at a luncheon in Christ Church. Among those who came were Profs. Arrhenius, Barker, Barus, Becquerel, Bleekrode, Ciamician, Cornu, Deslandres, Franchimont, Egoroff, Gautier, Körner, Le Chatelier, Liebreich, Martius, Michelson, Moissan, Nasini, Newcomb, and Sivewright.

In a convocation held the same day, the honorary degree of D.C.L. was conferred upon Profs. Becquerel, Körner, Liebreich, Moissan and Newcomb.

The following were the speeches made by the Regius Professor of Civil Law, Dr. H. Goudy, in presenting them.

Nihil pulchrius nobisque optatius est quam viros e gentibus externis de scientiarum studiis optime meritos societati nostrae adscribi atque arctissimo et dignitatis et amicitiae nobiscum vinculo consociari. Quae res hodie Universitati nostrae contigit quae eos viros, quos mihi adstare videtis, communi omnium ejus membrorum consensu (Instituti quod dicitur Regii annum centenarium feliciter actum commemorans) insigniri jussit.

BECQUEREL.

Primum ad vos duco virum illustrem, Gallica stirpe oriundum, qui in scientia physicae famam eximiam est adeptus, patris in eadem scientia illustris filius. Physicae studiosorum in manibus sunt scripta ejus praeclara principiis scientiae illius illustrandis destinata. Operum numerum quorum auctor doctus ille exstitit referre longum est; neque tamen, ut plurima praeteream, silentio praetereunda videntur opuscula illa, publici juris facta, in quibus de magnetis et electri proprietatibus felicissime disseruit, ipsamque Naturam, rerum creatricem, in lucem proferre coegit quanam ratione quaedam corpora aliquando lumina emittant atque vires electricas eis transmissas per longum tempus retinere possint.

KÖRNER.

Praesento vobis virum egregium, Germanica stirpe oriundum, inter eos qui praecipuam curam rebus chemicis dederunt notissimum. Quantum in ea parte Naturae profecerit, quam multa ingeniose et subtiliter excogitaverit, mihi exponere minime concedit sermonis academici egestas! Quid de compositis aromaticis ab eo recte libratis, quid de ἰσομοιρία, ut Graeco utar vocabulo, corporum in conjunctione naturali disseram?

Audisse sit satis kunc de his studiis ita meritum ut omnibus inter nostrates qui se iisdem studiis maxime devoverint dignus omnimodo laureâ nostrâ videatur.

LIEBREICH.

Salutamus deinceps virum e finibus Germaniae insignem. Ille secreta cerebri feliciter rimatus ad ipsa materiae atoma penetrando phosphorum capitalem Phosphorus et Lucifer ipse clarissimus nobis primo patefecit. Idem acerbissimos animi corporisque dolores impune extinxit,

Spargens chlora venena soporiferumque papaver.

Immo somnum insomnibus attulit, mollem, mortique simillimum.

MOISSAN.

Praesento vobis virum illustrem Lutetiis Parisiorum professorem. Viri hujus ingenium illustre, diligentiam, eruditionem in ea scientia quam ad illustrandam unice se devovit, jamdiu confessi sunt qui eadem in re florentissimi extiterunt. Sed nomini suo immortalitatem quandam justissimo titulo meruisse videtur, invento uno scientiae suae utilissimo; scilicet Fluorii elementum segregando, id quod nulli ante facere contigit, neque sine vitae periculo prioribus constabat experimentum hujusmodi; (scilicet qui sese ante nostrum experimento huic dedicaverant, duo, ante victoriam partam, occubuerunt, lauream tamen reportavit noster, periculo superstes atque, utinam diu superstes sit!)

NEWCOMB.

Sequitur deinceps vir insignis qui trans fluctus Atlanticos transvectus ad nos venit—senex antistes Naturae. Hunc virum scitote per multos annos astrorum motus rationemque coeli ita ingeniose perscrutatum fuisse ut multa non solum nova reperiat sed etiam sermone dilucido expressa argumentis confirmaret certissimis. Idem luminis velocitatem et quantum sol ab orbe terrarum distet singulari curâ investigavit, et tabulas Lunae motus correxit.

"Scire juvat magni penitus praecordia mundi."

At the Encænia, on June 21, the honorary degree of D.C.L. will be conferred upon the Earl of Elgin, Lord Kitchener, Sir Charles Parry, F. W. Maitland, F. D. Godman, Father Ehrle, Cecil Rhodes, and J. G. Frazer.

The eleventh annual report of the delegates of the University Museum (for 1898) is published in the *University Gazette* for June 6. This publication, which increases in dimensions every year, contains the reports of the Regius Professor of Medicine, the Linacre Professor of Comparative Anatomy, the Waynflete Professor of Physiology, the Professor of Human Anatomy, the Hope Professor of Zoology, the Professor of Experimental Philosophy, the Waynflete Professor of Chemistry, the Professor of Geology, and the Waynflete Professor of Mineralogy, and records substantial progress in all these departments.

Mr. E. S. Goodrich has been re-appointed Aldrichian Demonstrator of Anatomy.

Dr. J. F. Payne has been elected a member of the Medical Council of the United Kingdom, in place of Dr. W. S. Church, resigned.

Scholarships in Natural Science are advertised at the following Colleges:—Balliol, November 21; Merton, June 27; New, June 27; Magdalen, October 10; Corpus Christi, June 27; Christ Church, November 21; Trinity, November 21.

On June 14, a statue of Charles Darwin, by Mr. Hope Pinker, which has been presented to the University by Prof. Poulton, will be inaugurated at the University Museum.

CAMBRIDGE.—Mr. H. M. MacDonald, of Clare College, fourth Wrangler 1889, has been appointed University Lecturer in Mathematics in place of Prof. Love, now of Oxford.

Mr. A. E. Shipley, of Christ's College, has been re-appointed University Lecturer in Invertebrate Morphology.

The Adams prize for an essay on the Theory of the Aberration of Light has been divided between Mr. J. Larmor, F.R.S., Fellow of St. John's, and Mr. G. T. Walker, Fellow of Trinity, Senior Wranglers in 1880 and 1889 respectively.

The Smith's prizes for 1899 are adjudged to Mr. W. H. Austin and Mr. G. W. Walker, of Trinity, senior and fourth Wranglers respectively in 1897. Mr. Frankland, of Clare, and Mr. Whipple, of Trinity, receive honourable mention.

Prof. Thomson announces a course of demonstrations in Physics, to be given in the Cavendish Laboratory during the Long Vacation, beginning July 5.

The Council of the Senate propose to expend 125*l*. in preparing an appropriate exhibit for the Educational Exhibitions to be held in London and in Paris in 1900.

The accommodation in the new chemical laboratory is already insufficient for the numbers seeking instruction, and it is accordingly proposed to expend 609*l*. in adapting the attic story as an additional laboratory for elementary students.

The Senior Wranglership this year is divided between Mr. G. Birtwistle, of Pembroke, and Mr. R. P. Paranjpye, of St. John's. Pembroke has had no Senior Wrangler since Sir George Stokes in 1841, and does well thus to mark the year of his jubilee as Lucasian Professor. Mr. Paranjpye is a Mahratta student, who gained numerous distinctions in the University of Bombay before coming to Cambridge: he is the first native of India who has attained the highest mathematical honours. There are forty names (including two ladies) in the list of Wranglers, indicating that the "year" is a strong one.

In Part II., Messrs. Hudson, of St. John's, and Cameron, of Caius, are alone in the First Class (first division). These were senior and second Wranglers respectively in 1898. Miss F. E. Cave-Browne-Cave, of Girton, appears in the third division of the First Class.

In the Mechanical Sciences Tripos, Part I., six students have attained the First Class. In Part II. Mr. B. W. Head, of Emmanuel, has the First Class to himself. Mr. H. E. Wimperis, of Caius, has in the same Tripos qualified for his degree as an "advanced student."

Mr. J. E. Marr, F.R.S., of St. John's, is appointed a member of the General Board of Studies, in place of Dr. Langley, resigned.

Dr. D. MacAlister, Mr. C. E. Grant, and Mr. C. Warburton are appointed members of the new Board of Agricultural Studies.

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WE learn from *Science* that Dr. C. E. Beecher, professor of historical geography in Yale University, has been appointed to succeed the late Prof. O. C. Marsh as Curator of the geological collections of the Peabody Museum.

THE Education Department has received from Berne an announcement that an educational exhibition will be held in that city next autumn. The authorities organising the exhibition will welcome exhibits illustrating education in this country. Communications from those willing to take part in the exhibition should be addressed to the Director, Schweizerische Permanente Schulausstellung, Berne, from whom further particulars can be obtained.

WITH a view to assisting teachers of schools and classes to acquaint themselves with the methods and principles of natural science, especially as bearing upon aspects of school and class work, the Technical Instruction Committee of the Liverpool City Council have made arrangements with Prof. W. A. Herdman, F.R.S., Professor of Zoology at University College, to give a short course of lectures and laboratory demonstrations on the study of natural history.

IT has already been pointed out in these columns that the appointment of particular authorities to be responsible for technical and secondary education within their districts will reduce the overlapping which at present exists in many places. The London County Council was recently appointed as the sole authority to distribute the Science and Art grant in London, and as such it has taken exception to certain items of expenditure by the London School Board on technical or secondary education, on such lines as to compete injuriously with similar work in the Council's polytechnics and institutes in the same districts. The *Times* reports that the Local Government Board auditor has now ruled that such expenditure by the School Board is illegal, and can only be carried through as financial aid from the County Council. It is stated that the London School Board will appeal against this decision. Meantime, it is understood that the ruling will apply, not only to the London Board, but also to other School Boards throughout the country.

SOME statistics relating to engineering education are given by Dr. M. E. Wadsworth in a paper published in the *Transactions* of the American Institute of Mining Engineers. Engineering education in the United States has been, on the whole, a thing of comparatively recent date—the pioneer schools being the Rensselaer Polytechnic Institute, established in 1824; the Lawrence Scientific School, dating from 1846; and the Sheffield School, from 1847. But little further prominent work was done until 1863, when the Columbia School of Mines was established and followed rapidly by numerous other engineering schools,

The tables given by Dr. Wadsworth are not complete, but so far as they go they show that "in mining engineering the leading schools in the world, so far as shown from the records here published, are Freiberg, Leoben, Clausthal, Berlin, Paris, St. Etienne, Schemnitz, Przibram, Michigan College of Mines. California, Columbia, Lehigh, Massachusetts Institute of Technology, and Colorado."

AN account of the proposed Institute of Scientific Research for India, which Mr. J. M. Tata, of Bombay, has undertaken to endow with an annual income of a lakh and a quarter (125,000 rupees), is given by Sir Henry Acland in the second edition of his little volume, "Medical Missions in their Relation to Oxford" (London: Henry Frowde). As already announced, it is intended to found an institution which shall be, or correspond to, a Teaching University for India, concerning itself principally with post-graduate studies and scientific research. A committee has been organised to take the matter in hand and appeal for funds; and Mr. Tata's commissioner, Mr. B. J. Padshah, is making inquiries in Great Britain, in Europe, and in the United States, how best to carry out the scheme. Sir Henry Acland utilises the opportunity which the proposed scheme affords to accentuate his appeal that "a generous benefactor, or some great National Company, should complete in Oxford the Public Health Department for University Education in the subject of public health and anthropology, with special reference to Mr. Jamsetji M. Tata's great scheme for natural science in general, and sanitary science in particular, in India."

AN exhibition of practical work executed by candidates at the recent examinations of the City and Guilds of London Institute was opened at the Imperial Institute, on Friday, by the Duke of Devonshire. Referring to the character of the instruction given under the direction of this institute, His Grace remarked: The object of this instruction is to familiarise a student with all the processes and all the details the use of which is required in the trade he is going to undertake, and to show to him how the knowledge he has acquired in lectures or in books may be applied to the practical performance of his business. This exhibition, I hope, will help those who see it to realise the real need of the technical instruction now being given. If you sent students direct from the classes of the Science and Art Department into a workshop they would be utterly incapable, in all probability, of applying in a practical way the knowledge which they have acquired in the classes. If you separate by too long an interval the lecture-room from the workshop, the work will be lost, but if you combine the lecture-room with the workshop, you have the material from which we may reasonably expect that expert finished artisans will be provided, although, of course, perfect workmen can only be produced by long and continuous practice. The artisan students in the registered classes of the institute now number over 34,000, in addition to nearly 2000 students in its manual training classes, and of these numbers 13,800 were examined last year, showing an increase of 800 over any previous number.

## *SOCIETIES AND ACADEMIES.*

### LONDON.

**Royal Society**, April 20.—"Note on the Fertility of different Breeds of Sheep, with Remarks on the Prevalence of Abortion and Barrenness therein." By Walter Heape, M.A., Trinity College, Cambridge. Communicated by W. F. R. Weldon, F.R.S.

The paper is a brief abstract of information obtained from 397 sheep-breeders, who have supplied records of flocks containing 122,673 ewes for the breeding season of 1896–7.

The information obtained referred especially to the following eight pure breeds of sheep: Suffolk (7506 ewes), Kent (9931), Southdown (9134), Hampshire (26,400), Oxford Down (3555), Dorset Horn (10,285), Shropshire (8492), Lincoln (17,880). Besides these, returns were received for a small number of flocks for each of ten other pure breeds, referred to below as "various pure breeds" (10,010), and for certain cross-bred flocks (19,480).

*Fertility.*—The importance of fertility as a factor in the survival of a species is referred to, and some of the influences attending domestication which tend to reduce that importance are pointed out. Reference is made to Prof. Karl Pearson's account of the racial characteristic of fertility in the human species, and it is demonstrated that, in spite of the equalising effects of domestication, fertility in different breeds of sheep is also of a racial character.

Owing to the fact that the returns supplied by flock-masters of the number of lambs born are admittedly not always correct, and in view of the fact that the record of twins produced is considerably more accurate, statistics of the latter have been chiefly utilised for generalisations regarding fertility. These records show that the pure breeds dealt with stand in the following order:—

Suffolk (52·22 per cent. of twins), Shropshire (46·84), Dorset Horn (37·55), Oxford Down (35·02), Kent (31·38), Lincoln (29·09), various pure breeds (28·09), Hampshire (24·09), Southdown (18·67); that the average percentage of twins for these breeds is 30·02; and that the cross-bred flocks produce 31·04 per cent. of twins.

From this return, it is seen that the value of the Suffolk and Shropshire breeds, as prolific breeds, is incontrovertible, while the records of the Southdowns is so low as to show urgent need for close attention to the subject on the part of breeders. It is to be noted that several of the pure breeds show a higher rate of fertility than the cross-bred flocks.

The fertility of certain of the pure breeds is then examined with regard to locality, and it is demonstrated that while locality may affect the fertility of a breed, it does not do so to a sufficient extent to alter the racial characteristic of the fertility of the breed. The chief possible exception to this is found among flocks of Lincoln sheep kept in Yorkshire, in which the percentage of twins recorded is practically double the percentage obtained in the home county; but it is pointed out that, in this case, there are circumstances which indicate the difference is due to an abnormally low percentage of fertility in the Lincolnshire rather than to an especially high rate of fertility in the Yorkshire flocks.

The influence of management, of the condition, kind and amount of food available, of the season, weather, subsoil, and the age of breeding ewes upon the fertility of a flock was referred to.

Considering the percentage of lambs produced by the pure-bred flocks individually, it is seen that the percentage ranges, in 306 flocks, from 203·8 to 59·09 per cent., the most frequent percentage being between 110 and 120 per cent.

As regards the different breeds, the most prominent points demonstrated by this inquiry are the value of the Suffolk breed from a point of view both of fertility and low rate of loss from abortion and barrenness; the unsatisfactory condition of Southdowns, both as regards fertility and loss; the urgent need for investigation of the fertility of Dorset Horn ewes with rams of their own breed; and of the conditions affecting both fertility and loss in flocks of Lincolns in the home county.

**Physical Society**, June 9.—Prof. Lodge, President, in the chair.—The Secretary read a paper, by Mr. C. G. Lamb, on the distribution of magnetic induction in a long iron bar. A Lowmoor iron rod, whose length was 250 times its diameter, was taken, and a B–H curve plotted by ballistic measurements made with a search coil at the centre of the bar. The search coil was then moved along the bar, and the distribution of induction was determined for magnetising forces varying from $H = \cdot 74$ to $H = 35 \cdot 0$. Up to fields of 3·35 the induction leaks out more and more quickly as H increases, but above this value the induction tends to keep in more and more. From the curves obtained, the mean induction was deduced as well as the distance of the resultant pole from the middle of the bar. It is shown that this distance first decreases and then increases with the rise in field strength. According to the ellipsoidal theory, it should be constant. The bar was then made into a ring, and the B–H curves again determined. From these curves, together with known relations between B, H and $\mu$, curves showing the variation of $\mu$ along the bar were constructed. The Chairman gave a general explanation of the way the leakage depended upon the permeability in the case of a long iron bar.—A paper on the absolute value of the freezing point was read by Mr. Rose-Innes. The corrected values of the absolute value of the freezing point determined by Lord Kelvin from experiments on hydrogen air and carbonic acid contain discrepancies amounting to 1/3 per cent. between the carbonic acid and the hydrogen, while the separate measurements for carbonic acid agree among themselves to about 1/6 per cent. Starting with Lord Kelvin's equation for the forcing of a gas through a plug, the author has obtained a formula for the ab-

solute value of the freezing point, which can be worked out from the experimental researches of Regnault. The formula is based on the experimental proof by Joule and Kelvin, that the ratio between the cooling effect per atmosphere of differential pressure and the pressure is constant for all pressures. Applying data from Regnault's experiments to the formula deduced by the author, the values of the freezing point are practically the same as those given by Lord Kelvin. Hence it is thought probable that the discrepancies are due to inaccuracies in the experiments of Regnault which were conducted at constant pressure. The value of the zero calculated from experiments on hydrogen at constant volume made by M. Chappuis is, if we treat hydrogen as a perfect gas, 273·034. Applying a thermodynamic correction for the deviation of hydrogen from the laws of a perfect gas, the value of the freezing point becomes 273·19. This figure agrees very closely with the value 273·14 obtained by Lord Kelvin from the constant pressure experiments on air. The correction has only been applied to hydrogen, because in this case it is so small that a large percentage error in its determination has a very small effect upon the absolute value of the freezing point. In constant pressure work the experiments are difficult to carry out, and the correction is easily applied, while in constant volume work the experiments are easily performed, and the thermodynamic correction is difficult to apply. Prof. Gray expressed his interest in the manner in which Mr. Rose-Innes had obtained his results without using the experimental data of Joule and Kelvin, and pointed out that Lord Kelvin attached most importance to the results he had obtained for air. It would be useful to have the gas constants redetermined with greater accuracy. The compensating arrangement devised by Prof. Callendar would enable experiments at constant pressure to be carried out satisfactorily. Dr. Lehfeldt drew attention to the sign of the correction applied by the author, and asked if it should not be negative instead of positive. He pointed out that variation in the specific heat of a gas might affect the formula, and said that Boltzmann had shown that it was impossible to determine an absolute temperature without introducing calorimetric measurements. As Joule and Kelvin had sometimes found positive and sometimes negative values for the cooling effect in the case of hydrogen, large percentage errors might occur in the value of the correction. Mr. Blakesley asked what the probable error was in the numbers given by Lord Kelvin. Mr. Watson said that the author had calculated the value of the freezing point from experiments on hydrogen, and had shown that the result agreed closely with the value of the zero deduced by Lord Kelvin from experiments on air. He would like to know what agreement would be got by applying Mr. Rose-Innes' correction to the case of air. Mr. Rose-Innes, in replying, said he agreed with Prof. Gray that it would be useful to have the constants redetermined. It was only in their early work that Joule and Kelvin observed a cooling effect for hydrogen, the bulk of the experiments giving a heating effect. The sign of the correction depended on the increase or decrease of the effect with temperature, and was positive in the case of hydrogen. Regnault has proved experimentally that the value of the specific heat is constant.

**Chemical Society**, June 1.—Dr. W. H. Perkin, Vice-President, in the chair.—The following papers were read :—The hydrosulphides, sulphides and polysulphides of potassium and sodium, by W. P. Bloxam. The author has prepared substances of the following compositions :—

$$K_2S,2H_2O;\ K_2S,5H_2O;\ K_2S,12H_2O;\ Na_2S,9H_2O;$$
$$2KHS,H_2O;\ NaHS,2H_2O;\ NaHS,3H_2O;\ K_4S_5,10H_2O;$$
$$K_4S_8,6H_2O;\ K_4S_8,19H_2O;\ K_4S_9,xH_2O;\ K_4S_{10},xH_2O;$$
$$\text{and } Na_4S_9,14H_2O.$$

—On the relative efficiency of various forms of still-head for fractional distillation, by S. Young. The author has tested the efficiency of a number of forms of still-head in common use, and has devised new forms of greater efficiency.—The salts of dimethylpyrone and the quadrivalence of oxygen, by J. N. Collie and T. Tickle. The authors consider that dimethylpyrone chloride contains tetravalent oxygen, and has the following constitution :—

$$O{=}C\left\langle\begin{matrix}CH{:}CMe\\ CH{:}CMe\end{matrix}\right\rangle O\left\langle\begin{matrix}H\\ Cl\end{matrix}\right. .$$

—The symmetrical di-isopropylsuccinic acids, by W. A. Bone and C. H. G. Sprankling. By the action of isopropyl bromide on ethyl sodioisopropylcyanosuccinate and subsequent hydrolysis of the ethereal salt produced, the authors have obtained *cis*- and *trans*-di-isopropylsuccinic acid ; the dissociation constants have been determined.—Active and inactive phenylalkyloxyacetic acids, by A. McKenzie. Phenylalkyloxyacetic acids, in which the alkyl group is either ethyl, methyl, propyl or isopropyl, have been prepared from lævo and inactive mandelic acid ; in some cases racemation occurs.—The chemical composition of the oleo-resin of *Dacryodes hexandra*, by A. More. The oleo-resin of *Dacryodes hexandra* contains lævopinene, lævosylvestrene, a resin and a white crystalline substance which is probably ilicic alcohol.—The condensation of ethyl acetonedicarboxylate : the constitution of triethyl orcintricarboxylate, by D. S. Jerdan. The author has obtained a diethyl orcintricarboxylate as a new condensation product of ethyl acetonedicarboxylate ; the diethyl- and triethyl-salt both yield derivatives of two orcindicarboxylic acids, so that the constitution of triethyl orcintricarboxylate is determined.—A series of substituted nitrogen chlorides, by F. D. Chattaway and K. J. P. Orton. The authors have prepared a number of substituted nitrogen chlorides by aid of a reaction represented by the following equation :—

$$\left.\begin{matrix}R.CO\\ R'\end{matrix}\right\rangle NH + HOCl = \left.\begin{matrix}R.CO\\ R'\end{matrix}\right\rangle NCl + H_2O.$$

**Royal Microscopical Society**, May 17.—Mr. E. M. Nelson, President, in the chair.—Mr. C. L. Curties exhibited and described a new electrically heated stage for the microscope, made by Reichert. It was constructed so as to be heated by the current from the ordinary electric lighting supply. By an ingenious automatic arrangement the stage could be maintained at any required temperature to within 0·1° C.—Messrs. Watson and Sons exhibited a form of dissecting stage, designed by Mr. T. G. West, which could be used with any microscope without damaging the stage of the instrument when doing rough work.—The President called attention to some beautiful photographs of Mr. Grayson's rulings, taken by Mr. Wedeles.—Dr. Sorby's communication not being forthcoming, the President read a paper on the fine adjustment. He described the various forms which had been adopted from time to time, and said that in the course of his investigations he had discovered that Varley's inventions had been ascribed to others, and that the long lever fine adjustment generally ascribed to Ross was really first made by Powell.—The President then called attention to the exhibition of "pond life" by Fellows of the Society and Members of the Quekett Microscopical Club.

PARIS.

**Academy of Sciences**, June 5.—M. van Tieghem in the chair.—On the development in series of the integrals of differential equations by Cauchy's method, by M. Émile Picard.—Remarks on the formation of alcohol and carbonic acid, and on the absorption of oxygen by the tissues of plants, by M. Berthelot. Some remarks on a note in the previous number of the *Comptes rendus*, by M. A. Devaux. M. Berthelot recalls some experiments on the formation of alcohol made by him in 1860, and emphasises the necessity of very careful manipulation in experiments of this nature. Thus the alcohol may be driven off by a current of hydrogen at 110°, if the carbon dioxide is to be determined, or in a rapid current of steam if the isolation of the alcohol only is aimed at. If the manipulation of the leaves is not carried out as rapidly as possible, alcohol is readily formed during the process.—On the molecular refractions, molecular dispersion, and specific rotatory power of the combinations of camphor with some aromatic aldehydes, by MM. A. Haller and P. Th. Müller. The substances studied would be represented by the general formula

$$C_8H_{14}\left\langle\begin{matrix}C{=}CHR\\ |\\ CO\end{matrix}\right. ,$$

where R was $C_6H_5$, $C_6H_3O_2CH_2$, $C_6H_4(C_3H_7)$, and $C_6H_4(OCH_3)$. The results of the experiments are given in a table showing the molecular refractions of each of these substances for the rays Na, $H_\alpha$, $H_\beta$, $H_\gamma$, the molecular dispersion, and the specific rotatory power $(\alpha)_D$ at 20°, all determined in toluene solution. Both the molecular refractions and dispersions deviate strongly from the values calculated from the usual moduli, and this peculiarity is still more marked in the specific rotatory power, which for camphor is about 42°, and for these aldehyde camphors is of the order of 500°.—Construction of a plane mirror of 2 mètres diameter by mechanical methods, by M. P.

Gautier.—Stellar photographs taken with the large telescope of the Observatory of Meudon, by M. H. Deslandres. The telescope used had a great focal length (25 times the aperture, 60 cm.); the photographs taken of the moon, Jupiter, Saturn, and nebulæ are said to compare well with the earlier work of Pickering, Scheiner, and Lord Rosse.—Remarks on the preceding communication, by M. J. Janssen.—On the determination of reference points in the spectrum, by M. Maurice Hamy.—On indeterminate equations of two or three variables which have only a finite number of solutions in prime numbers, by M. Edmond Maillet.—On the partial differential equations of the second order with real characteristics, by M. J. Coulon.—On the calculation of the constant of rectilinear diameters, by M. E. Mathias. The method given for the determination of the constant $a$ is applied to the observations of Knietsch on chlorine. The value of the constant in this case is 0·5872, showing that the assumption made by Thorpe and Rücker that $a = 1$ is wanting in generality.—New galvanometric method, by M. Féry. When the torsional couple acting on the suspended portion of the galvanometer is weak, considerable uncertainty is introduced into the results by the uncertainty of the zero. By measuring the angular velocity with which the suspended system starts off, this difficulty is avoided.—On the use of potassium chlorate in explosives of the ammonium nitrate class, by M. H. Le Chatelier. From a solution containing potassium chlorate and ammonium nitrate, crystals of very constant composition and containing 5 per cent. of the former salt can be separated by modifying the temperature and composition of the mother liquor. These crystals, used instead of pure ammonium nitrate in safety explosives, have a greater certainty of detonation.—On the effect of low temperatures upon certain steels, by M. F. Osmond. The results of the experiments upon certain alloys of nickel and iron are in general agreement with those of Dewar and Fleming upon the same subject, the steel acquiring magnetic properties at the temperature of liquid air.—Action of phosphoretted hydrogen upon copper, cuprous oxide, and ammoniacal solutions of copper salts, by M. E. Rubénovitch. Metallic copper reacts with $PH_3$ at 180°–200° giving hydrogen and $Cu_3P$. Cuprous oxide reacts with the same gas at ordinary temperatures, giving the same copper phosphide and water. Various salts of copper, if treated in ammoniacal solution with hydrogen phosphide, behave differently according to the nature of the salt.—On the aloins, by M. E. Léger. Two distinguishing tests are given for barbaloin, and several derivatives are described prepared from the aloes of Natal.—On some derivatives of the unsymmetrical tetra-methyl-diamido-diphenylethane, by M. A. Trillat.—Study of some substituted diphenyl-anthrones, by M. L. Tétry.—On some colour reactions of the oxycelluloses, by M. Edm. Jandrier.—Contribution to the study of mineral waters: on the Croizat spring, near Mont Dore, by M. F. Parmentier. The results of an analysis of the water are given. Iron is absent, but salt and arsenic are present in notable quantities.—On mineral waters containing fluorine, by M. Parmentier. The waters analysed by the author contain no trace of any fluorine compound.—Modification of the respiration of plants produced by varying the temperature, by M. W. Palladine.—On the systematic position of *Trichophyton* and neighbouring forms in the classification of fungi, by MM. L. Matruchot and Ch. Dassonville.—The coal-bearing strata of the central Pyrenees, by M. Caralp.—Concerning the effect of blood serum in preventing the action of rennet, by MM. L. Camus and E. Gley. Reclamation of priority against M. A. Briot.—Coagulating action of the liquid from the external prostate of the hedgehog on the contents of the seminal vesicles, by MM. L. Camus and E. Gley.—Bunge's law, and the mineral composition of the newly-born infant, by M. L. Hugounenq.—Lesions of the nervous centres in experimental epilepsy of absinthe origin, by M. G. Marinesco.

## DIARY OF SOCIETIES.

*THURSDAY*, JUNE 15

ROYAL SOCIETY, at 4.—Prof. A. Michelson will read a Paper.—A Comparison of Platinum and Gas Thermometers at the International Bureau of Weights and Measures at Sèvres: Dr. J. A. Harker and Dr. P. Chappuis.—A Preliminary Note on the Life-History of the Organism found in the Tsetze Fly Disease: H. G. Plimmer and Dr. J. Rose Bradford, F.R.S.—The Colour Sensations in Terms of Luminosity: Captain Abney, F.R.S.—On a Quartz-Thread Gravity Balance: R. Threlfall, F.R.S.—On the Orientation of Greek Temples, being the Results of some Observations taken in Greece and Sicily in May 1898: F. C. Penrose, F.R.S.—And other Papers.

LINNEAN SOCIETY, at 8.—Contributions to the Natural History of Lake Urmi and its Neighbourhood: R. T. Günther.—A Systematic Revision of the Genus Najas: Dr. A. B. Rendle.—On the Anatomy and Systematic Position of some Recent Additions to the British Museum Collection of Slugs: Walter E. Collinge.—The Edwardsia Stage of Lebrunia, and the Formation of the Œsophagus and Gastro-cœlomic Cavity: J. E. Duerden.

CHEMICAL SOCIETY, at 8.—Ballot for the Election of Fellows.—On the Decomposition of Chlorates, with special reference to the Evolution of Chlorine and Oxygen: W. H. Sodeau.—The Action of Hydrogen Peroxide on Formaldehyde: Dr. A. Harden.—Homocamphoronic and Camphononic Acids: A. Lapworth and E. M. Chapman.—Action of Silver Compounds on α-Dibromocamphor: A. Lapworth.—The Colouring Matter of Cotton Flowers: A. G. Perkin.—Experiments on the Synthesis of Camphoric Acid: H. A. Auden, W. H. Perkin, jun., and J. L. Rose.—Methylisoamylsuccinic Acid, Part I.: W. T. Lawrence.

*SATURDAY*, JUNE 17.

GEOLOGISTS' ASSOCIATION.—Excursion to Lichfield and Cannock. Directors: Prof. C. Lapworth F.R.S., and Prof. W. W. Watts.

*MONDAY*, JUNE 19.

ROYAL GEOGRAPHICAL SOCIETY, at 8.30.—Exploration between Lake Rudolf and the Nile: Colonel J. R. L. Macdonald, R.E.

VICTORIA INSTITUTE, at 4.30.—Address by the Right Hon. Sir Richard Temple, Bart.

*TUESDAY*, JUNE 20.

ZOOLOGICAL SOCIETY, at 8.30.—On the Species of Cassowaries: Hon. Walter Rothschild.—On the Remains of a New Bird, *Praphaethon shrubsolei*, gen. et sp. nov., from the London Clay of Sheppey: C. W. Andrews.—On the Antipatharian Corals of Madeira: J. Y. Johnson.

MINERALOGICAL SOCIETY, at 8.—On the Constitution of the Mineral Arsenates and Phosphates. III. Plumbogummite and Allied Minerals: Mr. Hartley.—Note on Plumbogummite: Prof. Miers.—On a Pyroxene from South Africa: Mr. Bowman.—On the Chemical Composition of Tetrahedrite: Messrs. Prior and Spencer.—(1) On a Constituent of the Meteoric Iron of Youndegin, Western Australia; (2) On the Meteoric Stones which fell at Mount Zomba, British Central Africa, on January 25, 1899: Mr. Fletcher.

ROYAL STATISTICAL SOCIETY, at 5.—The Flag and Trade: A. W. Flux.

ROYAL PHOTOGRAPHIC SOCIETY, at 8.—Retouching: Redmond Barrett.

*WEDNESDAY*, JUNE 21.

GEOLOGICAL SOCIETY at 8.—Agglomerates, Ashes, and Tuffs in the Carboniferous Limestone Series of Congleton Edge: Walcot Gibson and Wheelton Hind.—Ironstone Fossil Nodules of the Lias: E. A. Walford.—Additional Notes on the Glacial Phenomena of Spitsbergen: E. J. Garwood.

ROYAL METEOROLOGICAL SOCIETY, at 4.30.—Heavy Falls of Rain recorded at the Observatories connected with the Meteorological Office, 1871–98: Robert H. Scott, F.R.S.—Average Height of the Barometer in London: R. C. Mossman.—A New Self-recording Anemoscope: Joseph Baxendell.

ROYAL MICROSCOPICAL SOCIETY, at 8.—Notes on some Sponges belonging to the Clionidæ obtained at Madeira: J. Y. Johnson.

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THURSDAY, JUNE 22, 1899.

## THE EXPERIENCES OF A ZOOLOGIST IN AUSTRALASIA.

*In the Australian Bush, and on the Coast of the Coral Sea: being the Experiences and Observations of a Naturalist in Australia, New Guinea, and the Moluccas.* By Richard Semon. With 86 illustrations and 4 maps. Pp. xv + 552. (London: Macmillan and Co., Ltd., 1899.)

ZOOLOGISTS have during the past few years reaped the benefit of Dr. Semon's travels in Australasia and in the Malayan Archipelago in the beautifully illustrated series of memoirs entitled "Semon, Zoologische Forschungsreisen in Australien und dem Malayishen Archipel," and published as part of the *Jena Denkschriften.* Five quarto volumes have already been published, running to some 1600 pp. and 113 plates, many of which are coloured. They contain memoirs on Ceratodus, Monotremes, Marsupials, Manis, the Dugong and other vertebrates, as well as important communications on various invertebrates; most of these have been contributed by well-known European specialists, Dr. Semon himself being responsible for the monographs on the development of Ceratodus, and of the Monotremes and Marsupials.

The large collections made by Dr. Semon having been carefully conserved, they have contributed considerably to our knowledge of tropical life from an anatomical as well as from a faunistic point of view.

On glancing over this monumental series of memoirs one is struck by the amazing activity of Dr. Semon both in the field and in the laboratory, and all zoologists must once more feel grateful to Dr. Paul von Ritter for his princely liberality in the cause of science.

But Dr. Semon has given us further cause for gratitude, as he has narrated his varied experiences of travel, and has recorded numerous observations on the habits of animals that would either have been unrecorded or buried in the obscurity of a technical treatise. More than this, Dr. Semon is not tainted with that half-cynical *fin-de-siècle* spirit which is too rife at present even amongst scientific men. There are men who appear to be ashamed of the interest they take in their own work, and who freeze younger men with a smile. The author of "In the Australian Bush," on the contrary, is not only a trained laboratory student, but he is a field naturalist as well. He revels in the varied aspects of nature, whether it be the monotonous Australian bush or a glorious tropical jungle, and he is not ashamed to let the reader share his joy and enthusiasm.

Dr. Semon left Europe in the summer of 1891 (in the preface it is 1892) for the purpose of collecting embryological material of the more interesting Australasian animals, and proceeded at once to the Burnett River; for it is only in the river systems of the Burnett and the Mary in South Queensland (latitude 25° to 26° S.) that the unique Ceratodus lives. This restriction of habitat is due to its avoidance of river heads, so that it cannot get conveyed by floods across a watershed; its being easily affected by sea-water, so that migration through the mouths of streams is impracticable; and to the eggs being so frail and tender that they cannot bear the most transient drying. Its survival in the Burnett and Mary Rivers is probably owing to some particularly extensive water-holes; should these ever dry up, this remarkable "living fossil" would become extinct. The fish is perfectly helpless out of the water, which it never leaves; neither does it form a cocoon, or indulge in a summer sleep like its African cousin Protopterus. The lungs enable it, by respiring air, to exist in the dry season in water-holes that are crowded with refugees from the river, and which soon become putrid by rotting animal and vegetable substances. Dr. Semon was greatly hindered in his collecting of embryological material by heavy floods, so he returned the following season, and was rewarded by obtaining a complete series of eggs and larvæ.

Of the habits of the Platypus (Ornithorhynchus), and especially of the Echidna, we have several interesting observations. A considerable number of eggs and embryos were obtained, and as much adult material as Dr. Semon cared to preserve. As the book is not intended for specialists, the author gives only sufficient anatomical information to enable the reader to appreciate the importance of his investigations, and all through the book we have short expositions of local problems of the geographical distribution of animals, which should enable the non-scientific reader to appreciate the chief reason why field-naturalists make such large collections.

Although most of Dr. Semon's investigations were concerned with land animals, he did some marine work in the Moluccas, where he went on a fruitless quest for the eggs of the nautilus during the months of January and February (1893). When at Ambon (the Amboyna of the Portuguese) he found that the nautilus is very rarely caught during the north-west monsoon, but that it was not unfrequently found during the south-east trade-wind. Two other instances have been observed by Dr. Semon of a periodical migration of marine animals from deep to shallow water for the purpose of depositing their eggs. The first was at Heligoland, in the case of the common starfish (*Asterias rubens*); the second was at Ambon, where the brilliantly coloured, flexible sea-urchin (*Asthenosoma urens*) wanders into shallow water only during the south-east monsoon. Interesting observations are recorded of the means by which sea-urchins are protected against the attack of certain rapacious marine snails that can spurt free sulphuric acid from their mouths in order to dissolve the calcareous spines and shells of these armoured echinoderms.

The natives of the various countries which Dr. Semon visited also attracted his attention, and he has given us his impressions in a pleasant manner; but he is less trustworthy when he passes from his own observations to general statements. For example, he says, "by far the most of the Queensland and New South Wales tribes are entirely devoid of religion" (p. 223). On the preceding page he asks, "Can one speak of religion to a people whose language possesses hardly any words for abstract expressions, and who have no sort of worship for any supernatural being, idolatry, sacrifice, and prayer being things unknown throughout Australia?" Worship of a supreme being, idolatry, and sacrifice may be unknown

in Australia; but Howitt wrote fifteen years ago (*Journ. Anth. Inst.*, xiii. p. 459), "I venture to assert that it can no longer be maintained that they have no belief which can be called religious." It is probably more correct to say that religion is intimately connected with nearly every act of the daily life of the Australian aborigine than to deny its existence.

While Dr. Semon gives a vivid account of the natives on the coast of British New Guinea from Yule Island to South Cape, he inadvertently falls into a few errors. It is true that the cranium of the Papuan is decidedly dolichocephalous in certain regions, but along the coast visited by Dr. Semon brachycephalism is almost as common as the other extreme. On more than one occasion the petticoats of the women are said to be made of coco-nut fibre, whereas this is never employed; the shredded leaf of the sago palm, however, is a very favourite material.

In the account of the murder of George Hunter by his native wife and her accomplices, the impression is given that the wife was entirely to blame. There is another version to this story, which is supported by the petition of the white ladies residing at Port Moresby for the free pardon of the wife. Although, as Dr. Semon is aware, the bow is not used by natives south of Port Moresby, he speaks (p. 373) in general terms for the "whole of South New Guinea" of birds of paradise being killed by "well-directed arrows." But on the whole there are few mistakes, and only a small number of verbal misprints. The general impression created by the book is correct, and the author's personal attitude towards the natives is most commendable. He refers in a kindly spirit to the excellent missionaries of varied creed, and is justly loud in his praises of the administration of Sir William Macgregor.

The illustrations, as a rule, are not particularly good, the views being reproduced from touched-up photographs; but for this there is a valid excuse, as the camera Dr. Semon took out with him did not stand the climate. Most of the figures of animals are evidently process blocks from pen and ink drawings, and they are somewhat hard and flat. There must necessarily be some defects in a book of travels, and especially in one which embraces so many subjects as this does; but the present writer would rather insist on the real excellence of the book, which has recalled happy memories of many similar experiences.

## AMERICAN NATURAL HISTORY.

*Chapters on the Natural History of the United States.* By R. W. Shufeldt. Pp. 480. Illustrated. (New York: Studer Brothers, 1897.)

ALTHOUGH bearing on its title-page the date 1897, for some reason or other copies of this work appear only recently to have been received in this country; and in reading the volume it is important that the date of publication should be borne in mind, as otherwise certain statements might be taken to indicate that the author was somewhat behind the time.

As a technical worker in several branches of zoology, Dr. Shufeldt has attained a well-merited reputation on both sides of the Atlantic; but, like many other naturalists of position, he is not above putting the results of some of his investigations and studies in popular form for the benefit of the "man in the street." And the present handsome and beautifully illustrated volume is in the main a reproduction of popular articles on various branches of natural history which appeared in American periodicals. Whenever he considered it necessary, the author has, however, made corrections and additions to the original text in order to bring it up to date. Although the greater portion of the matter relates to birds, the work naturally covers a wide field. We have, for instance, in addition to those on ornithology, chapters on the methods of study of natural history, classification of mammals, crayfish and crabs, sawfish, rays, and sharks, whales and manatees, various rodents, and bats and their habits. And in each and all of these the same level of interest, combined with instruction, that characterises the first is fully maintained.

Over many of his fellow naturalists, at least in Europe, Dr. Shufeldt has a very great advantage from the fact that he is an accomplished artist, both with the pencil and the brush, while he also makes full use of the camera. And in the first chapter of the volume he urges the extreme importance of the artistic power in the making of a good naturalist. Possibly he may lay an undue stress on the value of this capacity, but there can be no question that the "artistic eye" affords a guide in the correct diagnosis of allied animals that nothing else can replace.

And here it may be well to draw attention to the thoroughness of the author's methods of research, and the importance attached by him to observations in the field. The following, for instance, he gives as the method of procedure for a naturalist to adopt in describing an animal:—

"Having obtained all the possible light upon its habits in nature, and its geographical distribution, and every fact and fiction that has appeared in regard to it in literature—then seize upon all the material obtainable, enough in any event in order to fully exhibit the extremes of variation in size; the sexual characters; the eggs, embryos, and young at all stages; the fossil forms, if any are known; and finally, an abundance of similar material representing all the apparent allies of the particular form, either near or remote."

Then the specimens are to be examined anatomically, both macroscopically and microscopically.

"Having accomplished all this, we are prepared to use our laboratory notes in writing out an account of the species; naming it if the form be unknown to science; and suggesting a place for it in the system."

With such detail in his mode of working, Dr. Shufeldt, it is almost needless to say, is not a "species-maker."

And in this connection his opinion in regard to the species-making now going on in the States should certainly be quoted. When writing of the common chipmunk, for instance (p. 405), he says:

"Some of the other forms resemble it quite closely, while others depart more or less from it in the matter of size and coloration; some are distributed over a considerable geographical area, others being more or less restricted in their ranges, thus offering descriptive zoologists abundant opportunities to describe the fine

intergrading forms as new sub-species, an opportunity that has been fully availed of by a few ambitious mammalogists more anxious to add to a personal reputation than to be of any special use or aid to the science which they pretend to advance."

This is strong language, but there seems, in some instances, considerable justification for its use.

Of one of the above-mentioned chipmunks, a life-sized figure is given, which may be taken as a good example of the author's own sketches. Excellent as is this figure from a zoological standpoint, it cannot however compare in artistic effect with the reproduction of a photograph taken by the author of the deer-mouse (*Peromyscus leucopus*), which is perhaps the most exquisite in the whole book. The little creature is represented issuing from a maize-cob, on which it has been making a meal, and the half-frightened, stealthy expression of its head is most life-like. Although in our opinion the best of all, this is only one among a number of photographs of various beasts and birds taken by the author himself.

Of the few chapters devoted to mammals, all but one treat of the smaller representatives of the class; but, as if to make up for this, the one exception takes cognisance of the largest of living creatures—to wit, whales. After reading a statement in the introduction to the effect that technical matters were, so far as possible, excluded from the work, we confess to a feeling of surprise at finding nearly three pages of the chapter in question occupied by a technical list of American Cetaceans, many of the names in which are mere synonyms. Apart from this, the chapter is a remarkably interesting one, although it would have been better had some of the illustrations been reduced in size. In view of recent discoveries by the Prince of Monaco, we thought, on first reading the book, that the author was sadly behind the time in his statement that all the markings on Risso's dolphin are normal and not due to conflicts; but this apparent want of revision is fully explained by the date on the title-page. To the same cause may perhaps be attributed the author's relegation of *Zeuglodon* (misspelt, by the way, *Zenglodon*) to a position near the seals, as Prof. Damer's interesting memoir, in which its ancestral cetacean characters are so well brought out, was probably not published in time.

To refer to the other chapters would be to largely exceed our space; and all we can therefore do is to commend the work to the best attention of our readers as an admirable example of what popular natural history should be. Well printed and charmingly and profusely illustrated, it should be welcome alike to young and old, to the professed naturalist and to the non-scientific lover of nature. R. L.

## THE SONGS OF BIRDS.

*Cries and Call-Notes of Wild Birds.* By C. A. Witchell. Pp. xi + 84. (London: Upcott Gill, 1899.)

IN this book the author carefully describes the cries of over a hundred of the commoner species of birds which are to be heard in or near gardens of towns, woodlands, uplands and riverside. No reader who is at all interested in birds can fail to be impressed with the diligence and patience shown in collecting so much detailed information, and with the extraordinary powers of ear which the author seems to possess.

The cries of birds, as Mr. Witchell implies in his preface, are more readily distinguished from one another by differences of timbre than by differences of musical pitch. Owing to the fact that most birds sing at a very high pitch, it is exceedingly difficult for the human ear to recognise the intervals with certainty. Moreover, the vocal apparatus of a bird is such that he naturally produces several sounds within the compass of one tone of our musical scale; and it is for this reason that nearly all attempts to translate a bird's song into our musical notation are failures. Though familiar with the cries of most of the birds Mr. Witchell mentions, we have been quite unable to recognise several of the strains given in his book when played on the piano. Some of the musical illustrations would remind the hearer of the song if he were already familiar with it, but we doubt if they would convey much idea of it to any one else. Descriptions of the cries of birds by means of syllables and words are generally very difficult to interpret. It is easy to make the syllables fit the song when that is known, but the syllables give little idea of a song which is unknown to the reader, because there are no universally recognised rules for their pronunciation. Mr. Witchell has been at great pains, but we do not think really satisfactory results can be obtained in the representation of birds' cries by either of the methods he has employed.

There are few inaccurate statements in the book; but the author is mistaken when he writes concerning the song-notes of the great tit, "It is noteworthy that none of our other titmice have any of these cries." The coal tit sings a song not very unlike the ringing note of the great tit, which is represented by the words "chingsee, chingsee." We have spent many hours listening to grasshopper warblers; but we never yet heard one reel for five minutes without a break, nor for even half that time. And we think the author is unjust to the song of the mistle-thrush when he says, "the listener may be led to imagine that some very musical bantam or other such bird is crowing."

In the present work Mr. Witchell has not set himself to discuss the various problems concerning bird-notes, but he incidentally makes assumptions which seem to require more evidence to justify them. Thus he writes:

"In January and February the songs of the blackbird are much shorter than those heard in May, the young birds of the preceding year requiring some practice before attaining proficiency";

and again he says of the skylark:

"These autumn songs seem to be mostly those of young birds of the year, and consist mainly of repetitions of the call-notes, with the addition of a few more musical sounds."

We should like to have more evidence to show that these are songs of the young birds. It is well known that in February many chaffinches can be heard singing which apparently find it difficult to finish the song correctly. Mr. Witchell makes no mention of this; but surely he would not say that all these chaffinches are young birds.

There is yet another point on which we differ with Mr.

Witchell, and that is with regard to mimicry. Undoubtedly several birds are ready to mimic sounds which they hear about them, but it does not follow that every point of resemblance in the songs of two species is due to mimicry; it is quite as likely to be accidental. For instance, it seems to us fanciful to trace the origin of part of the song of a thrush in the following way:

"The 'kreeow' was given in the deliberate manner of the crow; the 'whillillill' was similar to the note of the wryneck; while the 'tewy' was clearly the call-note of the chiffchaff."

In another place we read:

"The nightingale is sometimes inclined to mimic, and one of its strains, a rapid 'slip slip slip' prolonged, is much like the sound made by the young perching nightingale when the parent is feeding it."

It seems curious that the nightingale should mimic the young birds when they are not yet hatched, for, in spite of the fact that nightingales are heard singing in mid-June, we do not believe that they generally sing after their young are hatched; and Mr. Witchell gives no evidence that the birds he heard were not delayed in their nesting owing to the destruction of their first nest.

Mr. Witchell is well known as a specialist in bird-song, and many of his observations could not be made without a carefully trained ear; so his book cannot fail to be of interest. We are doubtful as to the amount of help it would give to a novice wishing to become familiar with the various cries of birds; but it gives a fuller description of these cries than is generally to be found in ornithological works, and suggests many points which are worth further investigation. H. C. P.

## OUR BOOK SHELF.

*Psychologische Untersuchungen über das Lesen.* By Benno Erdmann and Raymond Dodge. Pp. viii + 360. (Halle, 1898.)

*The Story of the Mind.* By J. M. Baldwin. Pp. 263. (London: George Newnes, Ltd., 1899.)

Painstaking records of psychological experiments are, as a rule, not the most entertaining form of literature. Yet an exception must certainly be allowed in the case of the work of Drs. Erdmann and Dodge, which is no less distinguished by literary charm than by the thoroughness and completeness of the investigations it records. The greater part of this admirable work is devoted to a careful and, in the judgment of the present reviewer, unanswerable refutation of the opinion which since Wernicke has been current among German pathologists, that in normal reading the letters are spelt out separately, one after another. By a series of elaborate experiments the authors seem to establish beyond a doubt that our apprehension of a written text takes place exclusively during the pauses between the movements of the eye along the lines, that six to seven letters can be clearly perceived during each such pause, and finally that a short *word* of not more than four letters can be read off in less time than a single letter. In the later chapters Cattell's well-known experiments on reaction-times for written symbols are submitted to a searching criticism; and it is shown from the absence, under normal conditions, of conflicting optical suggestions or of conscious sensory-motor "feelings of innervation" that no element of "discrimination" or "selection" enters into our ordinary apprehension of the meaning of the symbol. As this means that simple apprehension is *not* "discrimination" of any kind, the result is an important one, and may be commended to the attention of those psychologists who still talk glibly of "discrimination" as the essential feature in perception. Altogether the book is a model of what a psychological monograph should be, clear, well-arranged, and most accurate.

Prof. Baldwin's little book is a valuable addition to the series in which it appears, and should awaken the interest of not a few intelligent general readers outside the little world of psychologists by profession. It is remarkable that he should have been able in so few pages to introduce his readers to almost every side of psychology. The most excellent feature of the book is probably the abundant illustration, from Prof. Baldwin's own researches, of the meaning and nature of psychological experiment. If one were in a fault-finding mood one might, perhaps, complain that the curious attack upon the teaching of language at p. 222 is both exaggerated and irrelevant, and that the concluding chapter on "The Genius and his Environment" is hardly definite enough in its results to justify its being reprinted from the popular magazine in which, no doubt, it has made a previous appearance. A. E. Taylor.

*Sewage Analysis.* By J. Alfred Wanklyn and W. J. Cooper. Pp. xiv + 220. (London: Kegan Paul, Trench, Trübner, and Co., Ltd., 1899.)

*Sewer Design.* By H. N. Ogden, C.E. Pp. viii + 234. (New York: John Wiley and Sons. London: Chapman and Hall, Ltd., 1899.)

The first of these two volumes is described as "a practical treatise of the examination of sewage and effluents from sewage." Many practical hints on the analysis and treatment of sewage are given; and the collection of original papers printed as an appendix contains useful notes and explanations on various analytical processes in chemistry. The object of the book is, however, stated to be to bring about a reformation in the analysis of sewage, and to point the way to its proper disposal. Apparently one of the chief reforms required, according to Mr. Wanklyn, is to induce chemists using the ammonia process of water analysis to express the readings of albuminoid ammonia in terms of parts per million, instead of parts per 100,000 and grains per gallon. But other reforms are urged; and as Mr. Wanklyn claims that "In some respects the opportunities enjoyed by my colleague and myself are absolutely unique," and remarks that "the severance of all relations with the London Chemical Society has operated to our advantage," the volume evidently contains criticisms and conclusions upon which a difference of opinion may be permitted.

Prof. Ogden's volume contains a course of lectures given in the College of Civil Engineering, Cornell University. It shows how the subject of sewer design may be dealt with scientifically, and therefore practically. Much scattered material upon points which have to be considered when preparing the design and making the plans for a system of sewers in a city, has been brought together by the author. Sanitary engineers will find the volume as serviceable for reference as students of sanitary engineering will find it helpful as a text-book.

*The Hygiene of the Mouth, a Guide to the Prevention and Control of Dental Diseases.* By R. Denison Pedley, F.R.C.S. Edin., L.D.S. Eng. Pp. 93. (London: J. P. Segg and Co.)

The importance of taking care of the teeth of children cannot be too strongly emphasised or too widely understood. In this volume the author describes the measures to be adopted for the prevention of dental diseases in adult life, the progress and treatment of dental caries, and some of the consequences of neglect of the teeth. The facts contained in the book should be known to every parent.

## LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### The Magnetic Compass and Nickel Cases.

IT is a common practice amongst instrument makers to put the magnetic compass needle of the pocket compass, or the marching compass used in the army, into an external case of nickel; the case is usually furnished with a lid, after the manner of a hunting watch, and is largely used by travellers.

Recently, while in South Australia, I used such a compass, which was lent to me, for the purpose of steering across a rather large "run." On comparing my position with that indicated by the map, I found that I had drifted considerably to the right of the point laid down; on examining the compass, while slowly shutting the lid, I noticed that as it closed the card of the compass was deflected. I next noticed that the case, which was much discoloured, and at first sight looked like bronze, was made of nickel; this revealed the source of error—when the lid was open, the nickel case, which is magnetic, was unsymmetrical with respect to the magnetic needle, and the needle was attracted by the lid from the true magnetic meridian, and the compass thereby rendered useless for steering purposes, and a source of possible danger, when long distances are traversed.

On talking over the matter with a leading instrument maker, I found that nickel is usually supposed to be a non-magnetic metal, and that nearly every traveller's compass case is made of nickel. It is somewhat remarkable, in an age of so many technical schools, that such ignorance can exist about a metal the properties of which were spoken of by Faraday in 1845 thus: "The magnetic characters of iron, nickel and cobalt are well known" (*Phil. Trans.*, 1846, p. 41). On looking through different price lists of leading firms selling marine compasses, I find that nickel enters into their construction also. In marine compasses the presence of a magnetic metal in the cases must be a source of some danger to the navigator. I would suggest that when selecting a magnetic compass, the magnet needle should be removed, and the case carefully tested for magnetic properties, and that should the case show any signs of magnetism it should be rejected. F. J. JERVIS-SMITH.

Oxford, June 13.

### Historical Note on Recalescence.

IN his recent presidential address to the Iron and Steel Institute, Prof. Sir W. Roberts-Austen stated (NATURE, No. 1541, p. 43): "To Gore, and to Barrett, we owe the investigation of the nature of a fact which had long been well known to smiths, that iron on cooling from a bright red heat suddenly emits a glow."

I do not know what authority Sir W. Roberts-Austen has for this statement, but as this is not the first time it has been made, perhaps I may be allowed to ask if he has any documentary evidence in support of it. So far as I am aware the history of the matter is as follows:—At the meeting of the British Association in Bradford in September 1873, I read a paper entitled "On certain remarkable molecular changes occurring in iron wire at a low red heat"; this was subsequently published in the *Philosophical Magazine* for December 1873. In this paper, the phenomenon, for which I suggested the name *recalescence*, was first described, and was further investigated in other papers of mine, to which I need not here refer. At the time of the discovery it seemed to me highly probable that this remarkable after-glow in cooling iron and steel was likely to have been already noticed, but after considerable search I could find no previous record of it in scientific literature; nor could I, after persistent inquiry, discover a single smith or iron-master who had even casually noticed the effect until I pointed it out to them.

But the most curious thing was that the observation had entirely escaped Dr. Gore's attention; in 1869, Gore discovered that a momentary elongation occurred in a cooling iron wire after it had been heated to bright redness. Dr. Gore, however, did not pursue the matter further, and informed me in May 1872 that he had no intention of doing so (see *Phil. Mag.*, December 1873, p. 473). Writing to me, after the publication of my paper in 1873, in a letter which I happen to have kept, Mr. Gore says:—

"Edgbaston, Birmingham, December 2, 1873. Your new discoveries respecting the molecular changes in iron, described in the *Phil. Mag.* for this month, have greatly pleased me; especially the sudden development of heat attending the elongation during cooling, and the sudden shortening during heating. . . ."[1] And in a letter to me some years later—after the delivery by Prof. Roberts-Austen of a lecture before the British Association in 1889—Dr. Gore naturally expressed his surprise that the discovery or investigation of recalescence should be attributed to him.

It is to M. Osmond more than any one else we owe the series of masterly investigations that has raised the discovery of recalescence into the importance which it now holds in the metallurgy of steel. The value of M. Osmond's work is well known, but I am glad of this opportunity of emphasising it, for M. Osmond's modesty has led him to attribute in his papers, and in his correspondence with me, more value to my own work than it probably deserves. For instance, in a letter addressed to me from Paris on December 13, 1889, M. Osmond writes:—"Vos observations sur la Recalescence sont de celles qui feront époque dans l'histoire de la métallurgie; elles ont été le point de départ de tout ce qu'on a fait pendant ces dernieres années, et pour mon compte, j'ai tant travaillé sur vos traces qu'il me semble vous connaître depuis longtemps. . . ."

I feel sure my friend Sir W. Roberts-Austen will forgive my venturing to correct him in this trifling matter of scientific history. It is quite possible his statement, that recalescence "had long been well known to smiths" prior to 1873, may be derived from his wide metallurgical knowledge, which I do not presume to possess, or it may arise from the common and unintentional blunder of reading our present knowledge into the past. W. F. BARRETT.

Royal College of Science, Dublin, June 2.

IN the Presidential address referred to, I attempted to review the progress made in connection with iron and steel during the past century. I felt that, notwithstanding the very limited space at my disposal for recording the work of individuals, the name of Barrett must find a place, and I greatly regret that my friend considers the reference to him to be infelicitous. As regards the first point raised by him (to take the class of smith's work with which I have most experience), those who have to conduct the very delicate operation of hardening dies for coinage have long been familiar with what is now known, thanks to Prof. Barrett, as "recalescence" in cooling steel. Of course the artificers were ignorant of its true cause, and they usually describe the effect of the sudden glow in steel as being due to "the heat coming from inside the metal." The fact that this industrial knowledge existed, does not in the least diminish the interest of Prof. Barrett's own observation (1873), nor lessen the vital importance of his work in showing that "Gore's phenomenon" (1869) is a reversible one. The relation of the work of Barrett to that of Gore was, moreover, indicated by me nearly ten years ago in the pages of NATURE (November 7, 1889, p. 16) as concisely as I could. In a recent number of NATURE (April 13, 1899, p. 567), a curve obtained by a method of my own is published, and it shows that there are no less than six points at which heat is evolved as iron cools down from 1150° C. to the ordinary temperature. I wish that Prof. Barrett, with his great experimental skill, had hastened the advance of our knowledge by continuing, during the past twenty-five years, investigations which would have led him to the discovery of the several very important points in carburised iron in which, as the

[1] In a note to the Iron and Steel Institute in 1890, and in correspondence with me subsequently, Dr. Gore points out that the discovery of the "sudden shortening during heating" he here attributes to me is more or less implied in his own paper in the *Phil. Mag.* for September 1870, where a molecular change occurring in iron during the process of heating is clearly mentioned. But the only evidence Gore gives of a molecular change during the *heating* of iron is the production of an induced current in a surrounding coil of wire when the iron core reaches a certain temperature; this he correctly attributes to the well-known change in the magnetic state of iron at this temperature. In fact, quoting from his previous paper, Dr. Gore states (the italics are his): "The iron during cooling . . . suddenly elongated by diminution of cohesion . . . a corresponding but reverse phenomenon did *not* occur during the process of *heating* the wire" (*Phil. Mag.*, September 1870, p. 171). In an interesting research on "The changes in length and temperature of iron and steel during recalescence," published in the *Phil. Mag.* for August 1898, M. Svedelius of Upsala supports the historical view I have here taken.

metal cools, the evolution of heat cannot be detected by the unaided eye. I may add that I fully share with M. Osmond, with whom I have so long worked, his appreciation of the value of Prof. Barrett's investigation.

Royal Mint, June 9. W. C. ROBERTS-AUSTEN.

## Harvesting Ants.

IN the spring of 1878 I was much amused with watching the apparent want of common sense displayed by the harvesting ants in storing the little fruits of the plane-tree (*Platanus orientalis*) in one of the avenues at Mentone. It was with much interest, on revisiting the Riviera in May this year, that I observed the same clumsy methods still being adopted by these ants under the plane-trees, not only at Mentone, but also at Hyères and Alassio.

Comparing the fruits to an umbrella in which the ribs are represented by the parachute of long hairs springing from the base or narrower end, while the upper and broader end is frequently surmounted by the remains of the style forming the handle of the umbrella, the ants in bringing the fruits to the nest, hold them pointing out in front, carrying them by the handle. On reaching the entrance, one would naturally suppose they would push them in as one pushes an umbrella into a stand, with the hairs pointing upwards. This would be comparatively easy, as the hairs in question would close round the fruit and offer no obstruction. Instead of doing this, the ants take the trouble to turn round and reverse the fruits, and then attempt to drag the tiny umbrellas in by the handle, the ribs pointing downwards and catching against the sides of the aperture. A large amount of time and energy is wasted by the ants in tugging and struggling with the fruits in order to make them go in, and very often a considerable number of ants are kept waiting about the entrance laden with similar spoil until their turn comes. Occasionally when the aperture is large the fruits go in more easily, but this is exceptional. The considerable "midden" of hairs outside the nests is evidence that the ants remove and reject the hairs after taking all this trouble.

I have never seen the ants carry a fruit into their nests with the hairs pointing upwards, except when I have thrust one well into the aperture in this position, and I have known the ants to reverse the fruits after I have tried to make matters easier for them. The present observations show (1) that after twenty years' experience in the same avenue at Mentone the ants have not learnt such a simple lesson as the proper way to get plane-tree fruits into their nests; (2) that this apparent lack of ingenuity is not restricted to the ants of one particular place, but is shared by the harvesting ants all along the Riviera; (3) that the ants know one method, and one method only.

June. G. H. BRYAN.

## Bessel's Functions.

THE phrases quoted by Prof. Gray furnish additional examples of the laxity of style amongst scientific men, to which "C. G. K." has called attention.

The English language does not readily afford a means of converting the name of a person into the corresponding adjective; and the result is that a slovenly practice has grown up of using the name itself as an adjective. In certain instances, this practice has become sanctioned by usage; and whenever this is the case, the *same* word must be regarded as doing duty for the proper noun and the corresponding adjective. But the practice is not to be commended, and ought always to be avoided if possible.

In my former letter, the word *conception* is a misprint for *corruption*. A. B. BASSET.

Fledborough Hall, Holyport, Berks, June 16.

## Limnology.

As introduced by Prof. Forel, and widely accepted by scientific men in all countries, the term *Limnology* is applied to the science of lakes exactly as *Oceanography* is applied to the science of oceans. It is consequently with some surprise, and even a little shock, that I find a review in the current issue of NATURE headed "Limnology," and dealing with the small organisms of drinking-water. These have been termed *Limnoplankton* by some writers; but treated from the practical point of view their study is surely not Limnology, and from any point of view only a very small part of it. When a scientific term is new and tender, it runs some risk of unintentional abuse which may impair its future usefulness; and I would appeal to scientific writers not to allow *Limnology* to fall into the confusion which now attends *Physiography*. HUGH ROBERT MILL.

THERE is, no doubt, some measure of justice in the remarks of your correspondent. More stress might have been laid on the fact that the book in question, in spite of its title, is much concerned, not only with the numbers, distribution, and seasonal abundance of the organisms in lakes—as stated on p. 147 of the review—but also with statistics regarding the temperature of the water at various depths and seasons, the penetration of light, and other physical phenomena coming under the head of Limnology in the sense required. THE REVIEWER.

June 17.

## "Index Animalium."

WILL you allow me to appeal through your columns for the loan of any of the books in the following list? I wish to see them in order to complete my manuscript from 1758–1800, now rapidly preparing for the press. Parcels may be addressed to me, care of Dr. Henry Woodward, F.R.S., British Museum (Nat. Hist.), London, S.W., and any books lent will be carefully returned in the course of a few days. No other editions are wanted.

Bourguet, L. "Traité de Petrif." 8vo, Paris, 1778.
Catesby, M. "Hist. Nat. Carolina," fo., Nurnberg, 1770.
Doeveren, G. "Abb. Würmer Mensch. Korpers.," 8vo., Leipzig, 1776.
Edwards and Catesby. "Receuil des Oiseaux," 8vo, Nurnberg, 1768–76.
Grossinger, J. B. "Hist. Nat. Hongrie," 8vo, Buda, 1794.
Guidetti, G. "Vermi umani," 4, Firenze, 1783.
Happe, A. F. "Abb. Schmetterling Afrikas," fo., Berlin, 1783–4.
Hiller, J. F. "De Papiliones ferali," 4, Witemb., 1761.
Houttuyn. "Museum," 8vo, Amsterdam, 1786.
Humphrey, G. "Mus. Humfredianum," 8vo, London, 1779.
Lancklavel. "Zerbst Kunst u. Nat. Kabinet," 8vo, Leipzig, 1777.
"Leipziger Magazin f. Naturkunde," for 1785–6–7 and 8.
Le Vaillant, F. "Naturges. Afrik. Vogel." (Bechstein's ed.), 4, Nurnberg, 1797–1802.
Le Vaillant, F. "Naturges. Afrik. Vogel." (Forster's ed.), 8vo, Halle, 1798.
Le Vaillant, F. "Reise innere Afrikas," 8vo, Frankfurt, 1790–97.
Linnæus. "Systema Naturae" (Müller's ed.), 2 parts, 8vo, Nurnberg, 1796 and 1809.
Linnæus. "Systema Naturae" (Vanderstegn van Putte's ed.), 4 v. 8vo, Bruxelles, 1793 and 1796.
Linnæus. "Systema Naturae" (Panzer's ed.), 8vo, Berlin, 1791.
"Magazin d. ausland Insekten," 1 No., 8vo, Erlangen, 1794.
Meyer, F. A. A. "Versuch 4 füssiger Thiere," 8vo, Leipzig. 1796.
Nau, B. S. "Oek. Nat. Fische Mainz," 8vo, Frankfurt, 1788.
Nau, B. S. "Beitr. Nat. Mainzelandes," 8vo, Mainz, 1787–8.
Pezold, C. P. "Lepidopt. anfangsgrunde," 8vo, Coburg, 1796.
Quensel, C. "Diss. Hist. Nat. ignotis Insect," 4, Lund, 1790.
Schneider, J. G. "Amphib. Physiol." (Spec. iii.), 4, Trajecti, 1797.
Schaffer, J. C. "Element Entom." (ed. 3), 4 Regensburg, 1780–87.
Theil, M. "Abb. würm. mensch. Leiber," 8, Berlin, 1766.
Turk, C. W. C. "Verz. meiner Insect. Sammlung," 4, N. Strelitz, 1799.
Wartel, C. P. "Mém. Limaçons Artois," 12, Arras, 1758; and ed. 2, 1768.
Wolff, E. J. "De Verm. intest.," 4, Giessen, 1763.
Wolff and Frauenberg. "Abb. Beschr. Franken Vogel.," fo., Nurnberg, 1799. C. DAVIES SHERBORN.

### Habits of the Cuckoo.

ONE day last week I was in my garden—a not particularly private country one—when I heard a cuckoo close by, and, standing quite still, I saw the bird alight upon an apple tree not more than four yards from me. The bird did not appear to object to my close proximity, for it uttered its call "cuckoo" twice. Its mate then came and sat in a plum tree only five yards from me, on the opposite side of me; one of them had a caterpillar in its mouth. Then a blackbird came into another tree in a state of great excitement uttering its "pink pink," as I supposed, at the cuckoos; and the question arose in my mind, "Does the cuckoo feed its own young, and was that in the blackbird's nest?" Can any of your readers help me?

WM. H. WILSON.

Gloucester House, Sudbury, Harrow, June 19.

### Economic Entomology.

CAN you tell me where I can get information as to the present condition of economic entomology in this country, more especially as to methods of research usually adopted?

Z.

## MAGNETIC PERTURBATIONS OF THE SPECTRAL LINES.[1]

THE subject which we are about to consider this evening forms a connecting link between two of the most interesting branches of human knowledge—namely, that which treats of magnetism and that which treats of light. Almost as soon as the properties of magnets became known, mere curiosity alone must have prompted philosophers to ascertain if any relation existed between magnetism and "the other forces of nature," as they were generally termed. We are consequently led to expect amongst the records of early experimental investigations some accounts which treat of the action of magnetism on light.

### *Early Experiments.*

When we seek for such accounts, however, we find that they are almost wholly absent from the literature of science, and this arises, I believe, from the great difficulty of the investigation and from the circumstance that only negative results were obtained, rather than that no such inquiry suggested itself or was undertaken. Even in quite recent times this inquiry has been prosecuted, but without success, by physicists who have published no account of their experiments. We may take it, therefore, that the inquiry is in itself an old one, although it is only now that it has been carried to a successful issue.

The earliest recorded attempt to solve this problem with which we are acquainted, is that of a celebrated British physicist whose name must for ever shed lustre on the annals of the Royal Institution—I speak of Michael Faraday. In order to understand the nature of the investigation which Faraday took in hand, and which has led up to the discourse of this evening, it is best to consider briefly some elementary facts concerning magnetism and light.

### *Magnetic Field of Force.*

In the first place, I shall assume that we know in a general way what the peculiarities of a body are which lead us to say that it is magnetised, or a magnet. These are that, when freely suspended, it sets itself in a definite direction over the earth's surface, as illustrated by the compass needle, and that in the space around it there is "magnetic" force exerted on pieces of iron, and, in a smaller degree, on other substances. For this reason, we say that a magnet is surrounded by a magnetic field of force. The field of force is simply the space surrounding the magnet, and it extends to infinity in all directions from the magnet. Near the magnet the force is strong, and far away from it the force is almost insensible; and so we say that the field is strong at certain places near the magnet, and that it is weak at places far away from the magnet. The direction of the force at any point is the direction in which the north pole of another magnet would be urged if placed at that point, and the push which this pole experiences may be taken to represent the intensity or strength of the magnetic field at the point in question. This is represented diagrammatically by these drawings [referring to figures suspended before the audience], which show roughly the nature of the field of force surrounding an ordinary bar magnet, a horse-shoe magnet, and the much more powerful form—the electro-magnet. It will be seen that the space outside the iron is filled with a system of curved lines running from the north pole to the south pole of the iron core. Where the lines are closest together there the magnetic force is strongest, and the direction of a line at any point is the direction of the resultant magnetic force at that point—that is, the direction in which a north pole would be urged if placed at that point.

Faraday always pictured the magnetic field as filled with lines of force in this way, and the importance of the conception can scarcely be over-rated, for it leads us to view the magnetic action as being transmitted continuously through the intervention of some medium filling all space, rather than by the unintelligible process of direct action at a distance. This medium is called the ether; but as to what it is that is actually going on in the ether around a magnet, we cannot definitely say. It may be that there is a flow of ether along the lines of magnetic force, so that there is an out-flow at one end of the magnet and an in-flow at the other, or it may be that the ether is spinning round the lines of force in the magnetic field. For our present purpose, it is not a matter of very much importance what the exact condition of the ether may be in a magnetic field, for if the ether in a magnetic field is either in some peculiar condition of strain or of motion, and if light consists of an undulatory motion propagated through this same ether, then it may be naturally expected that some action should take place when light is propagated through, or radiated in, a magnetic field of force. This is what Faraday suspected, and in order that we may appreciate the problem with which he had to deal, let us place ourselves in his position and ask ourselves the question: "In what manner can we test experimentally if there is any magnetic action on light?"

### *Tests for Magnetic Action on Light.*

In answer to this question, the first thing that occurs to us is to pass a beam of ordinary light through the magnetic field, in some chosen directions, and examine by all the means at our disposal if any action has taken place. When this is done we find that no observable effect is produced. But the scientific investigator does not rest satisfied with one negative result. He varies the conditions of the experiment, and returns to the attack with renewed vigour and hopes. In our first trial we passed a beam of light through the air-filled space around the magnet, and we may vary this experiment either by removing the air altogether, and so causing the beam to traverse a vacuum, or we may replace the air by some dense transparent substance such as glass or water. Under these new conditions, we still fail to detect any influence of the magnetic field on a beam of ordinary light. This negative result might arise from the field of force being too weak to produce an observable effect, or it might be that the effect, if any effect really does exist, may be of such a character that it is impossible to detect it with ordinary light. In common light, the vibrations take place indifferently in all directions around the ray, and follow no law or order as to their type. They

[1] Friday evening discourse delivered at the Royal Institution, May 12, by Thomas Preston, M.A., D.Sc., F.R.S.

possess no permanent relation to any direction around the ray, so that if the magnetic action should happen to be a twisting of the vibrations round the ray, it will be impossible to detect this twist in the case of ordinary light.

*The Faraday Effect.*

As a matter of fact it is a twist of this kind that actually happens, and this is probably what Faraday anticipated. In order to detect it, therefore, it is necessary to employ a beam of light in which the vibrations are restricted to a single plane passing through the ray. Such light is said to be plane polarised, and may be obtained by transmitting common light through a doubly refracting crystal. Faraday found that when a beam of this plane polarised light is passed through the magnetic field, in the direction of the lines of force, a distinct effect takes place, and that the effect is a twisting of the plane of polarisation of the light vibrations as they pass through the magnetic field, or, to be more precise, as the light passes through the matter occupying the field.

This is the Faraday effect. Its magnitude depends on the strength of the field, and upon the nature of the matter through which the light passes in that field. This latter is an important fact that should not be lost sight of in reasoning upon the nature of this effect. The presence of matter in the field appears to be necessary. The effect is not observed in a vacuum, but becomes greater as the field becomes filled with matter of greater density. It is therefore not a direct action of the magnetic field on the light vibrations, but rather an indirect action exerted through the intervention of the matter which occupies the magnetic field.

This action, as we have said, is a rotation of the plane of polarisation of the beam of light, and it arises from the circumstance that in passing through the magnetic field vibrations which take place from right to left do not travel forward with the same velocity as those which take place from left to right. There is no change in the periods of the vibrations, it is essentially a change of velocity of propagation that occurs. If we examine the transmitted light with a spectroscope, we find that the wave-lengths are unaltered, but that the amount of rotation of the plane of polarisation is different for waves of different lengths. The law which governs the effect is that the rotation of the plane of polarisation varies inversely as the square of the wave-length of the light employed.

*Second Form of Experiment (Faraday and Fievez).*

You will have noticed that in the foregoing experiment the source of light was placed quite outside the field of magnetic force, while the beam of light was transmitted through the field for examination. Now we might place the source of light itself in the magnetic field, and then examine if the light emitted by it is in any way affected by the magnetic force. This variation of the experiment suggests itself at once, and was indeed also tried by Faraday—in fact, it formed his last experimental research of 1862, but without success. The same experiment has been tried, no doubt, by many other physicists with the same negative result.

The first recorded success, or at least partial success, was by M. Fievez in 1885. He placed the source of light—a gas flame impregnated with sodium vapour—between the pole-pieces of a powerful electro-magnet. This being done, the light radiated by the flame was passed through the slit of a highly dispersive spectroscope and examined. What M. Fievez observed was that the bright spectral lines became broadened by the action of the magnetic field on the radiating source. His account is, perhaps, somewhat confused, owing to his imperfect apprehension of the true nature of the phenomenon which he observed, but, without doubt, he observed a true magnetic effect on the radiated light—namely, this broadening of the spectral lines—but he did not convince the scientific world that he had made any new discovery, and so the matter fell into neglect until it was revived again in 1897 by the now celebrated work of Dr. P. Zeeman.

*Work of Zeeman, Lorentz, and Larmor.*

The credit which attaches to Dr. Zeeman's work is that he not only, after prolonged effort, succeeded in obtaining this new magnetic effect, but he also convinced the world that the effect was a true one, arising from the action of the magnetic field on the source of light. That Dr. Zeeman was able to do this was due, perhaps, as much to the present advanced state of our theoretical knowledge of this subject as to his own skill and perseverance as an observer; and this is a striking example of the great assistance which well-founded theory affords to experimental investigation. The theory connects the facts already known in reasonable and harmonious sequence, predicts new results, and points out the channels through which they must be sought. Without such scientific theory, this general systematic advance would be impossible, and new results would be stumbled on only by accident.

To see how this applies to our case, we revert to the fact determined by Dr. Zeeman—namely, that when the source of light is placed in a strong magnetic field the spectral lines become broadened (see Fig. 1). As soon as

FIG. 1.—Shows the broadening of the spectral lines by the magnetic field. The upper row shows the lines when the magnet is not excited. The lower row shows the same lines when the magnet is excited. (Reproduced from a photograph, natural size.)

this was announced, Prof. Lorentz, and subsequently Dr. Larmor, examined the question from the theoretical point of view. They analysed the subject mathematically, and came to the conclusion that each spectral line should be not merely broadened, but should be actually split up into three—that is, each line should become three lines, or, as we shall say in future, a triplet. They also arrived at the further most important and interesting conclusion, viz., that the constituent lines of this triplet must be each plane polarised—the central line of the triplet being polarised in one plane, while the side lines are polarised in a perpendicular plane. In fact, the vibrations of the light forming the central line are parallel to the lines of magnetic force, while the vibrations in the side lines are perpendicular to the lines of force. This prediction of tripling and polarisation from theoretical considerations may be regarded as the key to the subsequent advance that has been made in the investigation of this region of physics. In order to understand it, let us place ourselves in Dr. Zeeman's position when he found that the spectral lines became broadened by the magnetic field, and let us be informed that this broadening is in all probability a tripling of the lines accompanied by plane polarisation. The question now is, "How are we to determine if this is the case?"

It is clear that if the broadened line is really a triplet, then the components of this triplet must be so close together that they overlap each other, and so appear to the eye merely as one broad line, as illustrated by the model which is here before you. [Model illustrating the overlapping shown here.] We know that the spectral lines are not infinitely narrow lines, but are really narrow bands of light of finite width, and consequently we are quite prepared to regard the magnetically broadened line as an overlapping triplet, but we cannot remain satisfied until we have proved beyond all doubt that it really is a triplet, and not merely a single broad line. To do this, Dr. Zeeman made use of the second prediction of the theory—namely, that the constituents of the triplet must be plane polarised. If this is so, then the outer edges of the broadened line must be plane polarised, and therefore by introducing a Nicol's prism into the path of the light it must be possible to turn the Nicol so that the plane polarised edges shall be cut off, and the breadth of the line shall be reduced to its normal amount. In fact in this position of the Nicol the outside lines of the triplet are extinguished, and the central component alone remains. This component is, of course, the same in width as the original line, and consequently when the outer members of the triplet are extinguished all the magnetic broadening of the line is removed. When the Nicol is turned through a right angle the central component of the triplet is extinguished, while

FIG. 2.—The lower row shows the lines uninfluenced by the magnetic field. The row next above shows the same lines broadened by the magnetic field. The top double row shows the analysation by a Nicol's prism. (Reproduced natural size.)

the side lines remain, and, if these side lines are sufficiently separated, so that they do not overlap, then, when the central line is removed, a narrow dark space will exist between the side components, which represents the space intervening between the outer members of the triplet, as illustrated by Fig. 2.

But even though we may be able to so increase the strength of the magnetic field that when the central component of the triplet is removed by a Nicol the side lines stand apart with a clearly defined interval between them, yet this in itself does not absolutely satisfy us that the broadened line is a triplet. It might be contended that the broadened line is not really a triplet, but is merely a band of light polarised in one plane along its edges, and in the perpendicular plane along its centre, and that increase of the magnetic field might never separate it into distinct constituents, but merely continue to broaden it. This contention, however, might be disposed of by a careful study of the facts, even though we might not be able to produce a magnetic field strong enough to completely separate the constituent lines of the triplet.

*Actual Triplets Obtained.*

But clearly the thing to be arrived at is to so arrange matters, in fact to so design our electro-magnet and to plan the conditions of our experiment, that the magnetic field acting on the source of light shall be strong enough to completely separate the members of the triplet if such exist. You will understand that this is no easy thing to do when you remember that it was only after repeated efforts and many failures that even a slight broadening of the spectral lines was obtained. Nevertheless, in spite of the great difficulty which besets this investigation, and which arises from our inability to obtain a magnetic field of unlimited strength, yet, with a properly designed magnet and other properly arranged conditions, it is possible to obtain a magnetic field strong enough to completely separate the constituents of the magnetic triplet, and thus to prove that the prediction of theory is verified by the actual facts.

*Other Perturbations, Complex Types.*

But with a magnetic field of great strength the facts as shown by these slides [photographs shown here] turn out to be more complicated and more interesting than the simple theory led us to expect. For while some of the spectral lines are split up into triplets as indicated by

FIG. 3.—The top lines are not subject to the influence of the magnetic field. Underneath the same lines are shown affected by a magnetic field of increasing strength. The line on the right is resolved into a pure triplet, while that on the right appears at first as a quartet, and finally in a very strong field as a sextet (easily seen on the negative). (Reproduced natural size.)

theory, some, on the other hand, become resolved into sextets, or octets, or other complex types (see Fig. 3). Thus when the magnetic field becomes sufficiently intense, we realise to the full all the theoretical predictions and more. The reason of this surplus of realisation over expectation lies in the fact that the theory in its simplest form deals only with the simplest types of motion under the simplest conditions, and the conclusions arrived at are of course of corresponding simplicity. When more complicated types of motion are contemplated, the theory furnishes us with the dynamical explanation of the more complicated types of effect produced by the magnetic field. That tripling pure and simple should occur in the case of every spectral line (as predicted by the simplest form of theory) is not a result which we should expect from a broader consideration of the problem. In fact, if we reflect on the subject, we are forced to the conclusion that deviations from the pure triplet type should be expected, and, as we have seen, such deviations actually do occur. In this respect,

therefore, the experimental investigation which yields more than the simple theory expected is not to be taken as in any way discordant with that theory, but on the contrary to be in harmony with it.

*Theoretical Considerations.*

In order that you may form some idea as to what it is that the theory supposes to be in operation in the production of these phenomena, I have had this elliptic frame constructed [model shown], which I ask you for the present to consider as the orbit described by one of those elements of matter which by their motions set up waves in the ether, and thereby emit what we call light. This white ball, which slides on the elliptic frame, is supposed to represent the element of matter. It is sometimes called an ion, which name is used to imply that the element of matter carries an electric charge inherently associated with it.

Now, under ordinary circumstances this ion revolving in its orbit with very great rapidity will continue to do so peacefully unless external forces come into play to disturb it. When external forces come into action, the orbit ceases in general to be the same as before. The orbit becomes perturbed, and the external forces are termed perturbing forces. But you now ask what is the character of the forces introduced by the magnetic field when the ion is moving through it. In answering this, we are to remember that the ion is supposed to be an element of matter charged with an electric charge—or, if you like, an electric charge possessing inertia. Now, if a charged body moves through a magnetic field, it is an experimental fact that it experiences a force arising from the action of the magnetic field on the moving electric charge. The direction of this force is at right angles both to the direction of motion of the charged body and to the direction of the magnetic force in the field. The effect of this force in our case is to cause the elliptic orbits of the ions to rotate round the lines of magnetic force; or to cause them to have a precessional motion [illustrated by model] instead of staying fixed in space, just as the perturbing forces of the planets in the solar system cause the earth's orbit to have a precessional motion. The angular velocity of this precessional motion is proportional to the strength of the magnetic field, and depends also, as you would expect, on the electric charge and the inertia associated with the ion.

This precessional motion of the orbit, combined with the motion of the ion around the orbit, gives the whole motion of the ion in space, and the result of this combined movement, of these two superposed frequencies—viz. the frequency of revolution of the ion in its orbit, and the frequency of rotation of the orbit around the lines of force—is that, in the case of the light radiated across the lines of force, each period becomes associated with two new periods, or, in other words, each spectral line becomes a triplet. A partial analogue to this, which may to some extent help you to understand the introduction of the two new periods, occurs in the case of sound, although the two phenomena at basis are quite different. The analogue (or quasi-analogue) is this. When two notes of given pitch, that is, of given frequency of vibration, are sounded together, their superposition produces two other notes of frequencies which are respectively the sum and the difference of the frequencies of the two given notes. These are known as the summation and the difference tones of the two given notes. Corresponding to these are the two side lines of the magnetic triplet. The frequency of the vibration in one of these lines is the sum, and the frequency of the other is the difference, of the two frequencies mentioned before—namely, the frequency of the revolution of the ion around its orbit and the frequency of the precessional revolution of the orbit round the lines of force. The centre line of the triplet has the frequency of the original vibration, and this frequency disappears completely when the light is viewed along the lines of force—that is, through axial holes pierced in the pole-pieces. In this direction, too, a further peculiarity arises, for not only does the triplet drop its central member and become a doublet, but each member of this doublet is not plane polarised, as the members of the triplet are. They are each, on the contrary, circularly polarised—that is, the vibration is circular instead of being rectilinear.

This all follows as the expectation of the simple theory which supposes that the ions are free to describe their elliptic orbits undisturbed by any forces other than the magnetic field. But it is only to be expected that other perturbing forces must come into play in the assemblage of ions which build up incandescent matter of the source of light. We know, for example, that the other members of the solar system perturb the earth's motion, so that it deviates from the simple elliptic motion predicted by the simple theory which did not take these perturbing forces into account. Hence, if any such perturbing forces exist, and we should be surprised if they did not exist, the tripling pure and simple of the spectral lines will be departed from, and other types will arise. From the character of these new types we may infer the nature of the perturbations which give rise to them, and hence by the study of these types we obtain a view of what is going on in matter when it is emitting light, which we should not possess if such perturbations did not occur. These deviations from pure tripling are consequently of more importance almost, in regard to our future progress, than the discovery of the tripling itself. To give you some idea of the influence of such perturbations in modifying the triplet form, I may mention that it follows, from simple theoretical considerations, that if the perturbing forces cause the orbit to revolve in its own plane, or cause it to change its ellipticity periodically, then each line of the triplet produced by the magnetic field will be doubled and a sextet will result, and other oscillations of the orbit will give rise to other modifications of the normal triplet type. It is not quite easy to see at once, however, what the perturbing forces are exactly, for we do not know the way in which the ions are associated in matter; but if we regard an ion as a charged element of matter describing an orbit, it will be analogous to a closed circuit, or to a magnetic shell, and will be urged to set in some definite way in the magnetic field. In coming into this position, it may oscillate about the position of equilibrium, and thus introduce an oscillation into the precessional motion of the orbit, which may have the effect of doubling or tripling the constituents of the pure precessional triplet.

Now, experimental investigation shows us that all the spectral lines do not become triplets when viewed across the lines of force in a magnetic field, for some lines show as quartets, or sextets, or octets, or in general as complex triplets derived from the normal triplet by replacing each component by a doublet or a triplet. We conclude, therefore, that the ions which give rise to these complex forms are not perfectly free in their motions through the magnetic field, but are constrained in some way by association with each other in groups, or otherwise, while they move in the magnetic field.

*Law of the Magnetic Effect.*

And now we come to a very important point in this inquiry. According to the simple theory, every spectral line, when viewed across the lines of force, should become a triplet in the magnetic field, and the difference of the vibration frequency between the side lines of the triplet should be the same for all the spectral lines of a given substance. In other words, the precessional frequency should be the same for all the ionic orbits, or the difference of wave-length $\delta\lambda$ between

the lateral components of the magnetic triplet should vary inversely as the square of the wave-length of the spectral line under consideration. Now, when we examine this point by experiment, we find that this simple law is very far from being fulfilled. In fact, a very casual survey of the spectrum of any substance shows that the law does not hold even as a rough approximation; for, while some spectral lines show a considerable resolution in the magnetic field, other lines of nearly the same wave-length, in the same substance, are scarcely affected at all. This deviation is most interesting to those who concern themselves with the ultimate structure of matter, for it shows that the mechanism which produces the spectral lines of any given substance is not of the simplicity postulated in the elementary theory of this magnetic effect.

*Grouping of Spectral Lines.*

Our previous knowledge of the line spectra of different substances might indeed have led us to suspect some such deviation as this from the results predicted by the simple theory. For if we view the line spectrum of a given substance we find that some of the lines are sharp while others are nebulous or diffuse, and that some are long while others are short—in fact, the lines exhibit characteristic differences which lead us to suspect that they are not all produced by the motion of a single unconstrained ion. On closer scrutiny, they are seen to throw themselves into natural groups. For example, in the case of the monad metals sodium, potassium, &c., the spectral lines of each metal form three series of natural pairs, and again, in the case of the diad group, cadmium, zinc, &c., the spectrum of each shows two series of natural triplets, and so on.

Thus, speaking generally, the lines which form the spectrum of a given substance may be arranged in groups which possess similar characteristics as groups. Calling the lines of these groups $A_1$, $B_1$, $C_1$ . . . $A_2$, $B_2$, $C_2$ . . ., $A_3$, $B_3$, $C_3$ . . . we may regard the successive groups as repetitions of the first, so that the A's—that is $A_1$, $A_2$, $A_3$, &c.—are corresponding lines produced probably by the same ion; while the B's—namely, $B_1$, $B_2$, $B_3$, &c.—correspond to one another and are produced by another ion, and so on. This grouping of the spectral lines has been noticed in the case of several substances, and it has been a subject of earnest inquiry amongst spectroscopists for some time past. All such grouping, however, up to the present, has had to depend on the judgment of the observer as to certain similarities in the general character and arrangement of the lines, and similarities which indeed may or may not have any specific relation to the mechanism by which the lines are produced. In fact, such grouping has been effected by guess-work, or by empirical formulæ, and we need not be surprised if it is found that the groups so far obtained are more or less imperfect.

I introduce this grouping of the spectral lines to your notice in order that we may attack the problem of reducing to order the so far apparently lawless magnetic effect. As I have already mentioned, the lines in the spectrum of any given substance are not all resolved into triplets by the magnetic field, but some are resolved into triplets while others become sextets, &c.; and further, the magnitude of this resolution, that is, the interval $\delta\lambda$ between the lateral components, does not appear at first sight to obey any simple law.

*Complex Atoms.*

According to the prediction of the simple theory, the separation $\delta\lambda$ should be proportional to $\lambda^2$, and although this law is not at all obeyed, if we take all the lines of the spectrum as a single group, yet we find that it is obeyed for the different groups if we divide the lines into a series of groups. In other words, the corresponding lines $A_1$, $A_2$, $A_3$, &c., have the same value for the quantity $e/m$,* or, as we may say, they are produced by the motion of the same ion. The other corresponding lines, $B_1$, $B_2$, $B_3$, &c., have another common value for $e/m$, and are produced therefore by a different ion, and so on. We are thus led by this magnetic effect to arrange the lines of a given spectrum into natural groups, and from the nature of the effect we are led to suspect that the corresponding lines of these groups are produced by the same ion, and therefore that the atom of any given substance is really a complex consisting of several different ions, each of which gives rise to certain spectral lines, and these ions are associated to form an atom in some peculiar way which stamps the substance with its own peculiar properties.

In order to illustrate the meaning of this, let us consider the spectrum of some such metal as zinc. The bright lines forming the spectrum of this metal arrange themselves to a large extent in sets of three—that is, they group themselves naturally in triplets. Denoting these triplets in ascending order of refrangibility by $A_1$, $B_1$, $C_1$, $A_2$, $B_2$, $C_2$, &c., we find that the lines $A_1$, $A_2$, &c., show the same magnetic effect in character, and have the same value of $e/m$, so that they form a series obeying the theoretical law deduced by Lorentz and Larmor. In the same way, the lines $B_1$, $B_2$, $B_3$, &c., form another series, which also obeys the theoretical law, and possess a common value for the quantity $e/m$, similarly for the lines $C_1$, $C_2$, $C_3$, &c. The value of $e/m$ for the A series differs from that possessed by the B series, or the C series, and this leads us to infer that the atom of zinc is built up of ions which differ from each other in the value of the quantity $e/m$, that each of these different ions is effective in producing a certain series of lines in the spectrum of the metal. When we examine the spectrum of cadmium, or of magnesium—that is, when we examine the spectra of other metals of the same chemical group—we find that not only are the spectra homologous, not only do the lines group themselves in similar groups, but we find in addition that the corresponding lines of the different spectra are *similarly* affected by the magnetic field. And further, not only is the character of the magnetic effect the same for the corresponding lines of the different metals of the same chemical group, but the actual magnitude of the resolution as measured by the quantity $e/m$ is the same for the corresponding series of lines in the different spectra. This is illustrated in the following table, and leads us to believe, or at least to suspect, that the ion which produces the lines $A_1$, $A_2$, $A_3$, &c., in the spectrum of zinc is

| Magnetic effect | Nonets or complex triplets | Sextets | Triplets |
|---|---|---|---|
| Cadmium ... ... $\lambda=$ | 5086 | 4800 | 4678 |
| Zinc ... ... ... $\lambda=$ | 4811 | 4722 | 4680 |
| Magnesium ... $\lambda=$ | 5184 | 5173 | 5167 |
| Precessional spin ... | $\frac{e}{m}=55$ | $\frac{e}{m}=87$ | $\frac{e}{m}=100$ |

[This table shows the effect for the three lines which form the first natural triplet in the spectrum of cadmium compared with the corresponding lines in the spectra of zinc and magnesium. It will be seen that the corresponding lines in the different spectra suffer the same magnetic effect both in character and magnitude. Thus the corresponding lines 4800, 4722, 5173 are each resolved into sextets, and the rate at which the ionic orbit is caused to precess is the same for each (denoted by $e/m = 87$ in the table). Similarly for the other corresponding lines.]

* The quantity $e$ is the electric charge of the ion, and $m$ is its inertia, and the ratio $e/m$ determines the precessional frequency, or spin, of the ionic orbit round the lines of magnetic force in a given field.

the same as that which produces the corresponding series $A_1$, $A_2$, $A_3$, &c., in cadmium, and the same for the corresponding sets in the other metals of this chemical group. In other words, we are led to suspect that, not only is the atom a complex composed of an association of different ions, but that the atoms of those substances which lie in the same chemical group are perhaps built up from the same kind of ions, or at least from ions which possess the same $e/m$, and that the differences which exist in the materials thus constituted arises more from the manner of association of the ions in the atom than from differences in the fundamental character of the ions which build up the atoms; or it may be, indeed, that all ions are fundamentally the same, and that differences in the value of $e/m$, or in the character of the vibrations emitted by them, or in the spectral lines produced by them, may really arise from the manner in which they are associated together in building up the atom.

This may be an unjustified speculation, but there can be no doubt as to the fascination which inquiry of this kind has always exerted, and must continue to exert, over the human mind. It is the speculation of the ignorant as well as of the philosophic and trained scientific mind, and even though it should never be proved to rest on any substantial basis of fact, it will continue to cast its charm over every investigator of nature.

It is ever the desire of the human mind to see all the phenomena of nature bound by one connecting chain, and the forging of this chain can be realised only gradually and after great labour in the laboratories of science. From time to time, the hope has been entertained that metals may be transmuted, and that one form may be converted into another; and although this hope has been more generally nurtured by avarice and by ignorance rather than by knowledge, yet it is true that we never have had any sufficient reason for totally abandoning that hope, and even though it may never be realised that in practice we shall be able to convert one substance into another, even though the philosopher's stone be for ever beyond our grasp, yet when the recent developments of science, especially in the region of spectrum analysis, are carefully considered, we have, I think, reasonable hope that the time is fast approaching when intimate relations, if not identities, will be seen to exist between forms of matter which have heretofore been considered as quite distinct. Important spectroscopic information pointing in this same direction has been gleaned through a long series of observations by Sir Norman Lockyer on the spectra of the fixed stars, and on the different spectra yielded by the same substance at different temperatures. These observations lend some support to the idea, so long entertained merely as a speculation, that all the various kinds of matter, all the various so-called chemical elements, may be built up in some way of the same fundamental substance; and it is probable that this protyle theory will, in one form or another, continue to haunt the domains of scientific thought, and remain a useful and important factor in our progress, for all time to come.

Even though it may be that a knowledge of the ultimate constitution of matter must for ever remain a sealed book to our inquiries, yet, framed as we are, we must for ever prosecute the extension of our knowledge in every direction; and in pursuing knowledge it frequently happens that vast acquisitions are made through channels which at first seem most unlikely to lead us any further. It has frequently happened that small and obscure effects, obtained after much labour and difficulty, have led to results of the highest importance, while very pronounced and striking effects which have forced themselves on the attention of the observer have proved comparatively barren. It was by a determined effort of this kind, founded on a correct appreciation of the importance of small outstanding differences—so small as to be despised or passed over by all other observers—that Lord Rayleigh discovered a new gas in our atmosphere, added argon to our list of elements, and initiated the attack which led to the brilliant capture by Prof. Ramsay of several new terrestrial substances.

Viewed from this standpoint, I hope I am to some extent justified in occupying your attention this evening with the consideration of the action of magnetism on light, for although the effect produced is small and not easy to observe, yet it is likely to prove an important instrument of research in the study of matter, and it is not inappropriate that a public account of what has been already achieved should be given in this Institution, in which the inquiry was first begun by Faraday, and in which his spirit still lives.

## *THE DOVER MEETING OF THE BRITISH ASSOCIATION.*

THE meeting of the British Association in Dover on September 13 this year promises, on account of its international character, to be a memorable one in the history of the Association. Dover was selected, though it is a smaller town than is usually chosen for these meetings, on account of its nearness to the French coast, in order that an interchange of visits should take place between the British Association and its French counterpart, which meets this year at Boulogne. The French Government has taken a great interest in the arrangements for the meeting, rightly judging that the meeting cannot but promote friendship and good will between the two nations. A good illustration of the truth that science has no nationality will be found in the fact that one of the evening lectures in Dover will be delivered in French by Prof. Chas. Richet, of Paris, on "La vibration Nerveuse." This will take place on Friday, September 15, at 8.30 p.m. It is extremely probable that Prof. Fleming will find some way of imparting an international character to his lecture on the "Centenary of the Electric Current," to be delivered on Monday, September 18.

The preliminary arrangements for the meeting are well in hand. The usual handbook is being prepared under the editorship of Dr. Sebastian Evans, brother of the ex-President of the Association, and will deal with Dover both in its ancient and modern aspect. The historical part of the subject has been undertaken by the Rev. S. P. H. Statham, Chaplain to the Forces, who has recently written a history of the castle, town, and port of Dover. The geology of the district is in the able hands of Prof. Boyd Dawkins; the botany in those of Mr. Sydney Webb. Dr. Parsons undertakes the climate, health and meteorology of Dover; whilst the harbour and cross-Channel traffic is described by Mr. A. T. Walmisley, C.E., the Harbour Board Engineer. This portion of the handbook should be extremely interesting in view of the national harbour which has been undertaken by the Government after more than fifty years' delay, and which will turn Dover into one of our most important naval ports.

For a town of its size Dover possesses an unusually large number of rooms suitable for public meetings, so little difficulty has been experienced in providing for the Sections. The Town Hall, with its annexe, the ancient Maison Dieu, will serve for the President's address and the soirées. The School of Art, in which five of the Sections assemble, adjoins and communicates with the Town Hall. The reception rooms and offices have an ideal *locale* in the buildings and grounds of the Dover College. This institution was founded some thirty

years ago in what remains of the Dover Priory, established about 1130. The magnificent Norman refectory will serve as the reception room and ticket office. The College is only about three minutes' walk from the Priory Station (L.C.D. Railway), and about as far from the Town Hall. Two of the Sections (anthropology and geography) will meet in a part of the town somewhat more remote from the reception room.

There will be no lack of entertainment of a public character. The General Commanding the South Eastern District (Sir Leslie Rundle) will give a garden party at the Castle; the Council, head-master and assistant-masters of Dover College will give another in the College grounds. The Mayor (Sir William Crundall) will give a conversazione, and will also give a reception one afternoon at the Dover Athletic Grounds, when there will be an exhibition and contest of motor cars from all parts of Europe and America.

The smoking concert, which was so successful a feature of the Bristol meeting last year, will be repeated. There will also be a military tattoo by torchlight on the sea front one evening, with music by the massed bands of the garrison.

The visit of the French Association is to take place on Saturday, September 16. The members will arrive early, and, after a light repast at the Lord Warden Hotel, will assemble at the Town Hall, when addresses of welcome will be given. An adjournment will then be made to the various Sections, which will meet on Saturday this year, though that day is generally an "off-day." In many Sections the presidents will reserve their presidential addresses for this occasion, so as to give the French guests a chance of being present. There will be a luncheon afterwards in a marquee in the College grounds. In the afternoon, parties will visit the Castle and other objects of interest in Dover. There may be opportunity for a visit to Canterbury.

On Sunday there will be special services in most of the churches and chapels of Dover, whilst those who care to go further afield can take advantage of the arrangements made by Dean Farrar, of Canterbury, one of the vice-presidents of the Association this year, for there will be special services in the Cathedral, with well-known preachers, and an organ recital in the afternoon. The Canterbury Museum, which owes much to the munificence of its Hon. Curator, Mr. Bennett Goldney, a most useful member of the Dover Local Committee, will be open to members of the Association on Sunday afternoon.

The return visit of the British Association to the French will take place on Thursday, September 21. The details are not finally settled, but there will be a *réunion* with addresses, a luncheon, the unveiling of a plaque to the poet Campbell, who lived at Boulogne for some time. A statue to the French man of science, Duchesne, will also be unveiled. It is intended to start from Boulogne on the five days' excursion through the most interesting towns of Northern France and Belgium. The civic authorities in each town have very cordially responded to the efforts of the French and the Belgian consuls in Dover, and have promised to do all in their power to make the five days' excursion a great success.

Amongst the scientific men from the Continent, the United States and Canada, who have already accepted the invitation of the Local Committee, may be mentioned Profs. Dwelshauvers-Dery, Fittig, Gobert, Julin, Kronecker, Calmette, Chappuis, Barker, Carl Barus, Surgeon-General Billings, Profs. Bovey, Campbell, Scott, Thurston, and Van Rijckevorsel.

From what has been stated, it will be evident that those members of the Association who visit Dover will have no cause to be dissatisfied with the programme before them.

W. H. Pendlebury.

## THE VOLTA CENTENARY EXHIBITION AT COMO.

In this age of electricity it is difficult to realise that only a hundred years have elapsed since the first electric current was produced by chemical means. The birthplace of Alessandro Volta has paid a fitting tribute to the pioneer of electrical science by holding an exhibition in commemoration of the discovery of the pile which bears the name of its inventor.

The Como Exhibition, which was opened on May 20, occupies a tract of land bordering on the Lake of Como, its natural surroundings harmonising well with the artistic arrangement of the buildings and exhibits. One section is devoted to electricity, another to the silk industries of Lombardy, while a small collection of pictures, church vestments, &c., forms a minor feature.

International Congresses of electricians and of telegraphists have been organised at Como. At the latter Congress, which was held on May 31, an inaugural address was given by Di San Giuliano, and a competition between professional telegraphists took place.

In the electric exhibits, applied electricity occupies, as might be expected, the most prominent place. All the machines in the exhibition, including the silk-spinning and weaving machinery, a lift to the top of one of the towers, and a high-pressure pump for supplying the fountains, are worked by electricity, each machine having a separate motor.

The principal source of power is a compound "Brünner" horizontal engine worked by steam supplied from two "Babcock and Wilson" boilers. The 150 horse-power thus supplied is transmitted to a steel shaft, where it can be increased up to 300 horse-power by a motor driven by a three-phase alternating current of 3600 volts, the generating plant for which consists of an engine of 100–150 horse-power by Wolf, of Magdeburg, and an alternator by Gadda and Co., of Milan. The main shaft can be connected with ten dynamos by different makers, varying from 24 to 300 horse-power, and as these cannot all be used simultaneously, a comparison of their efficiency is possible. Subsidiary electric power is supplied by three steam and two gas engines operating on dynamos, by Brioschi and other makers, and a fine series of accumulators is available for reinforcing the supply of power which, even without this help, is available up to 500 horse-power.

A large search-light exhibited by the Italian navy has been placed at Brunate, a station 1500 feet above sea-level, whence its rays can be flashed over Como and the surrounding district to a distance of many miles.

Technical instruction in electricity is well represented, while the purely physical side comprises exhibits of Röntgen ray apparatus, wireless telegraphy, electrostatic apparatus by A. Dall' Eco and other makers, and so forth.

One room in the exhibition buildings is set apart for the "Cimelii di Volta," under which head are comprised Volta's physical apparatus, original manuscripts of his papers, his letters, diplomas, and many of his personal effects. The greater part of these relics are exhibited by the Reale Istituto Lombardo, under whose auspices the collection was formed by public subscription in the years 1861 to 1864; for this collection, one of the rooms belonging to the Society at Milan has been specially set apart. Other relics, chiefly personal, are exhibited by Prof. Alessandro Volta and Prof. Zanino Volta. The University of Pavia exhibits several electroscopes, condensers, and similar electrostatic apparatus; and other exhibits are lent by the Como Museum.

The manuscripts include the following:—

(1) A letter to Volta from the French physicist Nollet, dated September 18, 1767.

(2) A letter from Volta to Prof. Barletti, of Pavia, dated April 18, 1777, containing an anticipation of the electric telegraph. Volta suggests the possibility of connecting Milan and Como with a wire suspended from poles, so that an operator at one end of the line could fire an electric pistol at the other.

(3) A manuscript dated May 14, 1782, dealing with animal electricity.

(4) Volta's paper of March 20, 1800, announcing his discovery of the electric pile to Sir Joseph Banks, President of the Royal Society.

(5) Volta's monograph on the formation of hail, published about 1806.

The apparatus exhibited illustrate Volta's inventions of the electrophorus and the "electric pistol," his application of gas to lamps, combined with an electric gas-lighting apparatus, his invention of the eudiometer, his researches on the capacity of condensers, his condensing electroscope, his investigations on the law of electrostatic force involving the use of the electric balances and the electrometer, his researches on atmospheric electricity, his studies on the expansion of gases, his first forms of voltaic pile, including the columnar pile represented by several examples, also the "crown of cups," and his early experiments on electrolysis. A number of batteries of Leyden jars, electrostatic machines, and other apparatus used by Volta in his experiments, while not referring to any special advancements in science, go far towards giving us an insight into the thoughts and pursuits of a physicist of a century ago, of whom the people of Como feel justly proud. G. H. BRYAN.

## *UNITED STATES GEOLOGICAL SURVEY.*

THE literature of American geology increases at an almost overwhelming rate. We have just received three large volumes containing 2053 pages of letterpress, including Part ii. of the Eighteenth Annual Report of the Survey for 1896-97, being papers chiefly of a theoretical nature; and Part v., the Mineral Resources, in two volumes. We have already called attention in NATURE for May 4 to some of the papers contained in Part ii., of which we received advance copies; these were on "The Triassic Formation of Connecticut," by W. M. Davis, with coloured maps and sections; on the "Geology of the Edwards Plateau and Rio Grande Plain adjacent to Austin and San Antonio, Texas, with reference to the occurrence of underground waters," by R. T. Hill and T. W. Vaughan; and "A Table of the North American Tertiary Horizons, correlated with one another and with those of Western Europe, with annotations," by Mr. William H. Dall.

In addition, this volume contains a report on the "Glaciers of Mount Rainier," by I. C. Russell, with a paper on "The Rocks of Mount Rainier," by G. O. Smith. Associated with the Cascade range in the State of Washington, but of later date and distinct from it both geographically and geologically, are four prominent volcanic mountains, of which one is Mount Rainier, 14,526 feet in height. This mountain is an extinct volcano, but the residual heat of its once molten rocks gives origin to steam-jets, which escape from crevices in the now partially snow-filled craters at the summit. The main mass consists of fragmental andesitic and basaltic materials, with some lava streams; but its outlines have been modified by frost and storms, and deeply sculptured by glaciers. The glaciers are now receding. The scenery around the mountain possesses such great beauty and grandeur that a portion of ground was reserved as a National Park in 1893, and it is now intended to reserve a larger area. Numerous views of the scenery are given.

"The Age of the Franklin White Limestone of Sussex County, New Jersey," is discussed by J. E. Wolff and A. H. Brooks. This limestone occurs in the Pre-Cambrian or Archæan highlands of New Jersey, an area largely occupied by gneisses. These schistose rocks have a nearly constant north-east strike and south-east foliation-dip, with a frequent linear parallel structure which is usually "inclined at a moderate angle to the north-east, lying generally in the plane of dip, and is called 'pitch.'" It is observed that the foliation structure in the limestone is usually parallel to that in the gneiss, and "the pitch structures of the gneiss, white limestone, and associated [magnetite] ore deposits have a general parallelism both in direction and angle." Mr. Wolff regards the pitch-structure as due to primary crystallisation. The authors conclude that the white limestone was deformed, metamorphosed, and partly eroded before the basal member of the Cambrian series was laid down.

"A Geological Sketch of San Clemente Island" is contributed by W. S. T. Smith. This island is the southernmost of a group known as the Channel Islands, which lie off the southern coast of California. It has no permanent human inhabitants except one old man, who has lived there most of the time for the last thirty years. Sheep, cattle and wild goats have been introduced, and there are foxes, lizards and land-shells. The vegetation is limited almost entirely to low shrubbery and herbage. The cactus and "salt-grass" are abundant. The island has a length of nearly twenty-one miles, a maximum width of little over four miles, and an altitude at one point of nearly 2000 feet. It is built up almost entirely of lava flows, with intercalated volcanic breccias and ashes. A detailed account of these is given. Miocene and later sedimentary deposits occupy small areas. The volcanic rocks appear to have been of Miocene age, but older than any of the sedimentary deposits. Attention is drawn to the evidence of faulting which occurred between the close of the Miocene and early Pliocene times, and which has had a marked effect on the physica features of the island. This faulting has continued at intervals ever since.

"The Geology of the Cape Cod District" is described by N. S. Shaler. He discusses the series of geological events which occurred since the beginning of the Cretaceous period in the south-eastern portion of New England. After tilting and the erosion of the Cretaceous and Tertiary beds, various Pleistocene deposits were laid down, and these in turn became somewhat disturbed. The region, in fact, has evidently been one of remarkable instability. A very full and interesting account is given of the structure of the region and of the glacial and post-glacial phenomena, illustrated by numerous views and sections.

"Recent Earth Movement in the Great Lakes Region" is the title of an article by G. K. Gilbert. He points out that although modern movements are of small amount, it is believed that they are of the same kind as the ancient, and that the great changes of the geologic past were effected slowly. His observations now lead to the conclusion that the whole North American lake-region is being lifted on one side or depressed on the other, so that its plane is bodily canted towards the south-south-west, and that the rate of change is such that the two ends of a line 100 miles long and lying in a south-south-west direction are relatively displaced four-tenths of a foot in 100 years. The changes are not directly obvious owing to inequalities of rainfall and evaporation, but the mean height of the lake-surfaces has been affected. With reference to the economic bearings of these changes Mr. Gilbert remarks that the modifications are so slow that they may have small importance in engineering works. He observes, however, that it is a matter of greater moment that cities and towns built on lowlands about Lakes Ontario, Erie, Michigan, and Superior will sooner or later feel the encroachment of the advancing

water, and it is peculiarly unfortunate that Chicago, the largest city on the lakes, stands on a sinking plain that is now but little above the high-water level of Lake Michigan.

The two volumes on mineral resources contain a large amount of valuable information, much of it statistical. The products for 1896 showed only a slight increase in value over those for 1895. There are lengthy reports on iron-ores, on the iron and steel industries of all countries, and on the Witwatersrand banket and other gold-bearing conglomerates, most of which appear to be marine. The evidence given in reference to these auriferous deposits shows that in ancient formations the detrital gold is most likely to be found in marine shore deposits. There are shorter reports on copper, lead and zinc, on aluminium with references to bauxite from Georgia and Alabama, on quicksilver, manganese, nickel, cobalt, antimony, and platinum; 163 ounces of platinum were obtained in the United States, and it is mentioned that a nugget weighing 20 ounces was found in Columbia, South America. Coal and coke are treated very fully, so also are petroleum and natural gas. Building-stones, clays, cement, precious stones, phosphates, mineral paints, and a variety of other substences are dealt with. It is noted that black shale is ground for the pigment known as mineral black. Fuller's earth has been reported from a number of localities. Observations have been made on various limestones considered likely to be useful for lithography, and it is reported that South Dakota promises to furnish suitable stone. The final report is devoted to mineral waters.

## *THE REPORT OF THE INTERNATIONAL AERONAUTICAL SOCIETY.*

THE International Meteorological Conference of Paris, 1896 (NATURE, vol. liv. p. 523) appointed various committees to discuss and report on certain scientific questions. One of these committees was entrusted with all questions connected with the science of aeronautics, such as the scientific use of balloons and kites.

Of this committee, Dr. H. Hergesell of Strassburg was the chairman, and Dr. W. de Fonvielle the secretary.

The committee held a meeting at Strassburg, March 31–April 4, 1898, and the report of this meeting, in two languages—German and French—has just appeared.

The meeting was attended by some twenty-five gentlemen, for the most part original or co-opted members of the committee.

During the interval of eighteen months between the meeting in Paris and that at Strassburg, several concerted balloon ascents had been organised and carried out. The area over which balloons, either manned or simply fitted with registering apparatus, had been sent up, extended from St. Petersburg to Paris, and a fair number of balloons took part on each occasion.

The chief business of the Strassburg meeting was to receive and consider the reports of these concerted experiments, and from the experience gained to arrive, if possible, at improvements in apparatus and arrangements for future work.

Among other matters, the preparation of sufficiently sensitive thermographs, to register sudden alternations of temperature, was especially recommended, and also the use of liquid air for the purpose of testing thermometers liable to exposure to extreme temperatures in unmanned balloons.

An interesting paper by Mr. Rotch on his kite work at Blue Hill Observatory, Massachusetts, was also handed in and included in the report.

Various special reports will be found in the appendices.

## *NOTES.*

A DEPUTATION will wait upon Mr. Balfour to-day to place before him reasons why national support should be given to an Antarctic expedition. It is understood that the Government is favourably inclined to the views of the deputation, and that the intention to make a grant towards the cost of the proposed expedition will be announced.

PROF. E. A. SCHÄFER, F.R.S., has been elected successor to the late Prof. Rutherford in the chair of physiology in the University of Edinburgh. Prof. Schäfer is forty-three years of age, and he has been Jodrell professor of physiology in University College, London, since 1863, when he succeeded Sir J. S. Burdon Sanderson.

THE annual conversazione of the Royal Society took place yesterday evening as we went to press.

SIR W. H. WHITE, K.C.B., F.R.S., will receive the freedom of the borough of Devonport on July 20, and will unveil, at the Technical School, a window descriptive of naval architecture.

DR. W. F. HUME, who during the last eight months has been carrying out a geological and topographical survey of the peninsula of Sinai, under the auspices of the Egyptian Government, has returned to Cairo with his survey party.

DR. CYRUS ADLER contributes to *Science* of June 2 and 9 a detailed account of the proceedings of the second conference on the International Catalogue of Scientific Literature, held at the Royal Society last October. The official Acta of the conference appeared in NATURE of October 27, 1898 (vol. lviii. p. 623).

M. PH. VAN TIEGHEM, Professor at the Museum of Natural History and President of the French Academy of Sciences, has been appointed to the chair of Biology of plants cultivated in France and the Colonies at the National Agronomic Institute, Paris; and M. G. Poirault succeeds the late M. Naudin as Director of the Laboratory for Higher Instruction at the Villa Thuret, Antibes.

PROF. ALFRED GIARD, the president of the section of zoology, anatomy, and physiology of the French Association for the Advancement of Science, has issued a circular in which he points out that as zoological members of the British Association will visit Boulogne, and attend some of the meetings of the French Association, the meeting will afford a good opportunity of discussing questions referring to pisciculture and marine fisheries. Papers dealing with the special zoology of the Channel or of the North Sea are therefore especially invited.

THE International Hydrographic and Biological Congress, which is to discuss the arrangement of periodical researches into the conditions of the North Sea and North Atlantic, was opened at Stockholm on Thursday last. M. Krusenstjerna, Minister of the Interior, delivered a speech, in which he welcomed the delegates in the name of the King of Sweden and Norway. Director-General Akermann (Sweden) was chosen president of the congress.

THE Liverpool School of Tropical Diseases is sending out to the West African coast a special expedition to investigate the causes of malaria and other diseases. The expedition will be headed by Major Ross, the recently-appointed lecturer, and will include Dr. Sunnett, the demonstrator to the Liverpool School. The party will start for Sierra Leone early in August, when the malarial season is at its height, and the conditions are most favourable for research. The expedition hopes to determine, by the methods which Major Ross employed in India,

which are the malaria-bearing species of mosquito in the locality chosen, and then inquire whether it is possible, by filling up the particular puddles in which they breed, to exterminate malaria in a given district.

ON Saturday last, the French naval authorities, acting in conjunction with Mr. Marconi, conducted some successful experiments with wireless telegraphy, between a ship and the shore in the English Channel. The French storeship *Vienne* was used for the purpose. Up to Saturday the distance between the South Foreland and Boulogne, about twenty-eight miles, was the greatest space through which these messages have been transmitted. On Saturday messages were sent between the vessel and the English coast from off Boulogne, and afterwards at intervals, until the vessel was twelve or fourteen miles away from that port. The greatest distance through which the messages were transmitted was forty-two miles. It is stated that Mr. Marconi's method of limiting the area of influence of the waves used was successfully applied. The messages were sent at will either to Wimereux or to the South Foreland, without the other station being able to intercept them.

A MARINE exploring expedition to the mid-Pacific, under the direction of Prof. A. Agassiz, is being arranged by the U.S. Commission of Fish and Fisheries. The expedition will leave San Francisco about the middle of August, and proceed directly to Tahiti, in the Society Islands, which will be made the headquarters while the Paumotu Islands are being explored. In this archipelago, which is about 600 miles long, the *Albatross* will pass six or eight weeks. After returning to the Society Islands, the vessel will go to the Tonga, or Friendly Islands, where a week or ten days will be spent. Thence the vessel will sail for the Fiji-Islands, where a short stay will be made, and thence to the Marshall Islands, visiting a number of the Ellice Islands and Gilbert Islands on the way. Six or seven weeks will be devoted to the exploration of the Marshall Islands. Between the Marshall Islands and the Hawaiian Islands, and between the latter and San Francisco, a distance of over 4000 miles, a line of deep-sea dredgings will be run, deep-sea townets being used while the dredging is going on. The *Albatross* is expected to return to the United States in April next year. Every effort is being made to thoroughly equip the vessel for deep-sea dredging, trawling and sounding; surface and intermediate towing; shore seining; fishing trials with lines and nets; land collecting, and other branches of the work. The newest apparatus for deep-sea and plankton investigations will be supplied. Special appliances are being constructed for use in the very deep water to be found about some of the islands.

A PARAGRAPH on the thermal conductivity of cast iron, as determined by Messrs. E. H. Hall and C. H. Ayres, appeared in NATURE of April 13 (p. 563). The thermal conductivity of the cast iron used was found to be about 0·1490 at 30° C. Mr. I. Thornton Osmond, Dean of the Pennsylvania State College, calls our attention to the fact that this result differs from values obtained under his direction in 1894, and described in the *Physical Review* of that year (vol. ii. No. 3, Nov.-Dec.). For the cast iron used in this investigation, the thermal conductivity from 60° C. to 90° C. or 100° C. was found to be a little over 0·09; and from 150° C. to 200° C. a little over 0·11. Mr. Osmond adds: "Though believing, from theoretical considerations, the conductivity to be a direct function of temperature, these figures were somewhat surprising; and I made preparation to have the work repeated through a greater temperature range and with great care; but this was never carried into effect. The method used was that of Principal Forbes, substituting thermopile and galvanometer for mercury thermometers, thus greatly reducing the cavities in the bar."

WE regret to learn that among other steps taken in reducing the expenditure of the Colony of Jamaica, it has been decided to withdraw the annual contribution towards the Weather Service, which has for the last eighteen years been under the control of Mr. Maxwell Hall, and to substitute a vote of 50*l*. for the collection and tabulation of statistics of rainfall and temperature. The letter from the Colonial Secretary seems to suggest that one reason for the step taken was that the full co-operation on the part of other Colonies and countries, which was necessary to make the scheme a complete one, was not forthcoming. The Service consisted of one first-class station, six stations of the second and third classes, and about two hundred rainfall stations. The vote was a very small one, and the director appears to have done good work, and to have been successful in issuing storm warnings and rainfall forecasts, although the latter could not reach those principally interested. Various useful investigations have been undertaken and published in the Jamaica Weather Reports, or elsewhere.

THE volume of hourly means of the readings obtained from the self-recording instruments at the five observatories under the Meteorological Council, just published for the year 1895, completes the lustrum 1891–1895; an appendix has therefore been added to the usual tables for the year in question, showing the mean values for that period. In addition to these values, hourly and other means of pressure, temperature and rainfall are given for four observatories, for a period of twenty-five years, and of sunshine for fifteen years. These averages afford valuable data for climatological or other more minute investigations. Further, in deference to a recommendation of the international meteorological conference at Paris in 1896, the hourly readings for some elements are given for two stations—Valencia Observatory as a typical Atlantic Coast station, and Kew Observatory as a typical inland station, and it is intended to continue this departure in future volumes.

PROF. ARRHENIUS contributes to the *Revue Générale des Sciences* an interesting account of his investigations into the causes of secular variations of temperature at the earth's surface. It is shown that widespread changes of mean temperature are more likely to be due to variations in the proportion of terrestrial rays absorbed by the atmosphere than to any variation connected with the solar rays, and that the absorption of terrestrial rays is most likely to be affected by changes in the amount of carbonic acid present in the atmosphere. Using Langley's data, it is calculated that if the amount of carbonic acid were diminished by a little more than half, the temperature would be lowered by about 4°·5 C., while an increase to two and a half or three times the present amount would raise the temperature about 8°·5 C., corresponding to the conditions of Glacial and Eocene times respectively. This calculation gives rise to some interesting speculation as to the possibility of such changes having taken place as the result of volcanic or erosive action, and the effect of the artificial consumption of carbon in raising the temperature of the air.

THE *National Geographic Magazine* for May contains a paper by Mr. J. B. Leiberg, entitled "Is climatic aridity impending on the Pacific slope?" The arid non-forested regions of eastern Oregon, and the semi-arid, sub-humid, and humid forest tracts are examined separately, and in each case evidence is found of adverse climatic change taking place in the direction of aridity.

THE parietal eye, with its adjacent organs, of the New Zealand Tuatera (*Sphenodon*) receives attention at the hands of Dr. A. Dendy in the May issue of the *Quart. Journ. Micr. Soc.* This functionless eye, which, although deeply buried in the integument, is better developed in the reptile named than in

any other animal, has hitherto been very generally considered as an unpaired organ. Recent investigations, especially those of the author, point, however, to the conclusion that it was originally dual, like the other sense-organs; and that the parietal eyes were once serially homologous with the functional pair now possessed by vertebrates. In the Tuatera, it is believed that the single parietal eye now developed belongs to the left side, its fellow being represented by an organ of essentially similar structure known as the parietal stalk.

In the June number of *Nature Notes*, Mr. R. Morley calls attention to the great destruction of monkeys on the Gold Coast for the sake of their skins. It is stated that in the five years preceding 1892 the average annual export of their skins reached 175,000, with a value of 30,000*l*. As skins in prime condition are alone purchased, this may be taken to represent a yearly slaughter of 200,000 monkeys, mostly belonging to a species of Guereza (*Colobus vellerosus*). In 1894 the number of skins was 168,405, valued at 41,001*l*.; but in 1896 the number fell to 67,600, with a value of 8,662*l*. This shrinkage tells its own tale; and if effectual steps are not forthwith taken to stop the slaughter, it may be considered as certain that in a few years this very beautiful species will be practically exterminated.

In one respect at least it appears that the Madras University is in advance of kindred institutions at home, as students of history are required to possess some knowledge of ethnology and comparative philology. Surely it is time that the anthropological basis of history and sociology was fully recognised in British universities and colleges. Even the enlightened Madras University has to confess that there are no facilities for practical instruction at the colleges. Fully realising that information merely derived from books or lectures is insufficient for education, Mr. Edgar Thurston, the superintendent of the Madras Government Museum, has, with characteristic energy and enthusiasm, supplied the deficiency so far as he is able, and last year gave a course of demonstrations on practical anthropology at the museum. Mr. Thurston not only instructed the students in the technical methods employed, but demonstrated the forms of skulls and external characteristics of the living, and showed how the statistics so obtained elucidated the problems of the migrations of peoples. The collections of prehistoric archæology in the museum afforded proof of the antiquity of man, and the ethnographical collections illustrated the present condition of various tribes.

The "Struggle between Peoples" is the title of a short paper in the *Bulletins de la Soc. d'Anthropologie*, viii. p. 604, by Félix Regnault, in which he opposes the ordinary view that conquered peoples take refuge in the mountains. It is true the last resistance to invaders is made in the mountains, but that is by the mountaineers, and not by the inhabitants of the plains who have been driven into the mountains. M. Regnault also discusses the effect of a nomad people coming into contact with agriculturists: in some instances, the agriculturists win, and the conquered occupy the less fertile or arid lands; in other cases, the pastoral people conquer the tillers of the soil, but though they temporarily overwhelm them, the latter persist and emerge, and the pastors eventually maintain themselves only in those lands which are favourable to keeping flocks.

A highly interesting and important contribution to the study of immunity is to be found in a paper by Rudolf Emmerich and Oscar Löw, published in a recent number of the *Zeitschrift für Hygiene*. The authors have obtained from cultures of the *B. pyocyaneus* an enzyme which, when inoculated into animals infected with virulent anthrax bacilli, is able to entirely negative the action of the latter. Success has also attended their efforts to immunise animals against anthrax infection. The method of preparing the substance, which they call "pyocyanase-immun-proteidin," is not yet perfect, and the details are promised in a later communication. This enzyme is also able to act deleteriously upon typhoid, diphtheria, and plague bacilli *in vitro*, and, curiously, is much more pronounced in its action under anaërobic conditions. It possesses a remarkable power of retaining its bactericidal properties under exposure to high temperatures. Thus 1½ hours of a temperature of from 85 to 90° C., and exposure for 1½ hours to a temperature of 98°·5, and being steamed for an hour at 98°·5 C., all fail to remove its beneficial characteristics. A prospect is now held out by these investigations of obtaining antitoxic substances in a far less costly and cumbrous manner than is involved in procuring curative serums through the medium of living animals; and perhaps the hope of the authors is not unjustified that, "by means of further improvements in immunising methods, the human and animal organisms may be ultimately protected from every conceivable kind of natural infection . . . it only depends upon obtaining the enzyme of certain pathogenic bacteria in the purest possible condition, and their harmless introduction into the body."

A curious instance of a polymorphous bacterium has been recently given by S. Hashimoto, of Sapporo (Japan), who, working in the Halle Hygienic Institute, has found a microbe which assumes at one time the appearance of small motile rods, at another that of thick, plump cocci hanging together in chains of from ten to twenty individuals, whilst yet more interesting is its assumption of the sarcina form, grouped together in packets consisting of from eight to sixteen individual cells. Every precaution was taken to meet the not unwarranted suspicion that these various appearances were simply due to working with an impure cultivation, but even such a master in technique as Prof. Fraenkl could discern no flaw in the manipulations, and moreover was able to confirm in every particular the interesting discovery of his pupil. The microbe in question was originally obtained from an agar-plate which had been mixed with imperfectly sterilised milk, previously kept for some days in an incubator.

In the June number of the *American Journal of Science* appears a full and detailed memoir of the life and works of the late Prof. O. C. Marsh, with a portrait. Especial interest attaches to the account of his early journeys into Indian territory; and the exposure of the nefarious treatment of the Indians themselves, which he was so largely instrumental in bringing about. The paper concludes with a complete list of Marsh's publications. The writer agrees with the opinion already expressed in this journal, that the time is not yet ripe for forming an adequate estimation of the late Professor's labours.

*Bulletin* No. 61 of the Massachusetts Agricultural College (Hatch Experiment Station) is devoted to an account of the life-history of the asparagus-rust, *Puccinia asparagi*, and of the best modes of treatment of plants infested with it.

In a recent number of Bonnier's *Revue générale de botanique*, M. Guignard records some remarkable observations on the mode of impregnation in *Lilium martagon*. He claims for the two generative nuclei of the pollen-tube the term "antherozoids," to indicate their homology with the corresponding bodies in Gymnosperms and in the higher Cryptogams. Although not provided with cilia, they both elongate and assume a vermiform appearance before entering the embryo-sac, the indications of a spiral form being still evident. The two "antherozoids" both take part in the process of impregnation, the one fusing with the ovum-cell or oosphere, the other with the

secondary nucleus of the embryo-sac, or with one of its constituent polar nuclei, to form the endosperm. There is, therefore, in *Lilium martagon*, according to M. Guignard, a double process of conjugation; but the union of the "antherozoid" with the secondary nucleus of the embryo-sac he regards as a process of "pseudo-fecundation." Similar results have been obtained by Prof. S. Nawaschin, and they have been confirmed by Miss Ethel Sargant in a paper read before the Royal Society on May 4.

THE third part of the series of memoirs, in course of publication by the Cambridge University Press, on the material collected during Dr. Arthur Willey's expedition to the Pacific in search of the eggs of the Pearly Nautilus, has just been issued. Three papers are contained therein, dealing respectively with orthogenetic variation in the shells of Chelonia, by Dr. Hans Gadow; Enteropneusta from the South Pacific, by Dr. Willey; and a collection of Echiurids, by Mr. A. E. Shipley.

AN account of the communications and discussions at the International Congress of Zoologists, which met at Cambridge in August last, was given in NATURE at the time of the meeting (vol. lviii. p. 424). A fine volume of *Proceedings*, edited by Mr. Adam Sedgwick, F.R.S., has now been published by Messrs. C. J. Clay and Sons. The volume contains the papers and addresses read before the congress, with reports of remarks made upon the subjects of these communications, and also during the discussions of specific points of zoological importance. Fifteen coloured plates are appended to the volume to illustrate some of the papers. The nature of the contents can be judged from our summary of the work of the congress, and the editor is to be congratulated upon being able to see the *Proceedings* published nine months after the meeting. Few official reports of international congresses appear with such commendable promptitude.

A DIAZO-BODY is a substance obtained by the interaction of nitrous acid and an amine (such as aniline) under certain conditions of temperature. Perhaps no other reaction in organic chemistry is so important either theoretically or technically, and it is so fundamental that the term "to diazotise" has been coined to express the operation. Diazo-compounds are of the general type $R.N=N.OH$, where R may be any benzene group ($C_6H_5$, and so on), and are distinguished by their great nstability and explosive power, tending to give off nitrogen. By very simple reactions the substance $R.N=N.OH$ may be made to give $R.OH$, $R.Cl$, $RBr$, $RI$, $RH$, $R.NH_2$, $R.NH.NH_2$. In many questions of constitution of benzene ring compounds, the exchange of the diazo-group for the sulphonic group is a necessary step in the argument. The methods hitherto proposed for carrying out this reaction give, in general, very bad yields and involve the production of evil-smelling thio-compounds as intermediary products. In a recent number of the *Berichte*, Dr. Ludwig Gattermann describes a very elegant method, the discovery of which, he states, was due to a happy accident which depends upon the formation of a sulphinic acid directly from the diazo-compound. The diazo solution, preferably as sulphate, is mixed with an excess of sulphuric acid and saturated with sulphur dioxide, and then treated at 0° C. with finely-divided metallic copper, when the sulphinic acid is formed in practically theoretical quantity. The method has been found to be of wide applicability, equally good yields being obtained in the naphthalene series.

THE additions to the Zoological Society's Gardens during the past week include a Hoolock Gibbon (*Hylobates hoolock*, ♂) from Upper Burma, presented by Mr. S. B. Bates; two Blue-bearded Jays (*Cyanocorax cyanopogon*) from Brazil, presented by Mr. Arthur Ussher; a Laughing Kingfisher (*Dacelo gigantea*) from Australia, presented by the Hon. A. Littleton; two Black-bellied Sand-Grouse (*Pterocles arenarius*) from Asia, presented by Mr. G. P. Torrens; twelve Sharp-headed Lizards (*Lacerta dugesi*) from Madeira, presented by Mr. R. H. Archer; two Green Lizards (*Lacerta viridis*), a Tessellated Snake (*Tropidonotus tessellatus*), a Common Snake (*Tropidonotus natrix*), European, presented by the Rev. F. W. Haines; a Northern Mocking-Bird (*Mimus polyglottus*) from North America, presented by Mr. C. Gillett; a Greater Sulphur-crested Cockatoo (*Cacatua galerita*) from Australia, two Spiny-tailed Iguanas (*Ctenosura acanthura*) from Central America, deposited; two Derbian Screamers (*Chauna derbiana*) from Colombia, two Palm Squirrels (*Sciurus palmarum*) from India, a Diamond Python (*Python spilotes*) from Australia, purchased; two Burrhel Wild Sheep (*Ovis burrhel*, ♂ ♀), two Jameson's Gulls (*Larus novae-hollandiae*), bred in the Gardens.

## OUR ASTRONOMICAL COLUMN.

TEMPEL'S COMET 1899 *c* (1873 II.)—M. L. Schulhof has calculated new elements and a continued ephemeris for this comet, using the positions supplied from the observations of Messrs. Perrine and Javelle, made at Lick and Nice respectively. *Astr. Nach.* (Bd. 149, No. 3574).

*Elements.*

T = 1899, September 6·0 Paris Mean Time.

$$\left.\begin{array}{ll} M = & 7^\circ\ 21'\ 50''\cdot5 \\ \pi = & 185\ 36\ 20\cdot0 \\ \Omega = & 120\ 57\ 56\cdot3 \\ i = & 12\ 38\ 52\cdot6 \\ \phi = & 32\ 49\ 38\cdot7 \\ \mu = & 671''\cdot9166 \end{array}\right.$$

($\pi$, $\Omega$, $i$: 1899·0)

*Ephemeris for 12h. Paris Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ ″ | Br. |
|---|---|---|---|
| June 25 | 20 8 16·8 | − 7 23 2 | 2·282 |
| 26 | 9 36·7 | 7 40 5 | |
| 27 | 10 56·1 | 7 57 54 | |
| 28 | 12 15·0 | 8 16 30 | |
| 29 | 20 13 33·4 | − 8 35 52 | 2·525 |

COMET 1899 *a* (SWIFT).—Dr. A. Stichtenoth, of Kiel, contributes a continued ephemeris of this comet to *Astr. Nach.* (Bd. 149, No. 3574).

*Ephemeris for 12h. Berlin Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ | Br. |
|---|---|---|---|
| June 22 | 14 38 41 | +27 37·1 | 0·27 |
| 23 | 36 6 | 26 39·4 | |
| 24 | 33 43 | 25 44·1 | 0·23 |
| 25 | 31 34 | 24 51·3 | |
| 26 | 29 34 | 24 0·8 | |
| 27 | 27 44 | 23 12·6 | |
| 28 | 26 3 | 22 26·4 | 0·17 |
| 29 | 14 24 31 | +21 42·3 | |

During the week the comet travels almost in a direct line between the stars ε and α Bootis. It can only with difficulty be now detected with telescopes of less than three inches aperture.

SPECTRA OF RED STARS (CLASS III. *b*).—In August last, 1898, results of a photographic study of the stars of Secchi's Type IV. (Vogel's III. *b*), made by Mr. Ellerman and Prof. G. E. Hale at the Yerkes Observatory, were discussed at the Harvard Conference (*Astro-Physical Journal*, vol. viii. p. 237, 1898). The photographs were obtained with a spectrograph having only one prism and a long-focus camera (20·0 inches). Since that time the spectrograph has been remodelled and provided with a train of three prisms and a shorter focus camera (10·8 inches), and with this instrument much better photographs have been obtained with shorter exposures. *Bulletin* No. 7 of the Yerkes Observatory contains a short description of these, with a plate showing the spectra of four stars of this class (*Astrophysical*

*Journal*, vol. ix. p. 271, 1899). The examination of the photographs has resulted in the possibility of arranging ten of the stars in a series indicating progressive evolution, and the four given are sufficiently representative to show the changes indicated. These are—

I. 280 Schjellerup = DM 59°·2810 (Magn. 7·8).
II. 273 ,, = 19 Piscium (Magn. 5·5±).
III. 132 ,, = U Hydræ (Magn. 5·5±).
IV. 152 ,, = (Magn. 5·5).

The presence of *bright lines* formerly announced is confirmed by these photographs, and some of these are identical with those observed visually by Prof. Duner at Upsala. Any attempt to establish a connection between these stars and those of other types must include these bright lines, but as yet no star is known intermediate in character between these red stars and other groups. In the absence of a suitable instrument for detecting such bodies at the Yerkes Observatory, advantage has been taken of an offer from Prof. Pickering to photograph suspected objects with the objective prism, and in case this indicates a body of new constitution, the 40-inch refractor and stellar spectrograph will be employed for its detailed examination.

The photographs extend from $\lambda$ 5150 to $\lambda$ 5850, the carbon fluting with maximum about $\lambda$ 563 being specially distinct in the spectra of 19 Piscium and U Hydrae.

*Bulletin* No. 9, in the same number of the *Journal*, p. 273, contains a plate illustrating a later attempt to find some position for these stars of Class III.*b* in the stellar constitutional system. The stars compared are—

I. The Sun (Type II.).
II. $\mu$ Geminorum (Type III.).
III. 132 Schjellerup (Type IV.).

In the region extending from $b_4$ to about $\lambda$ 5300, the spectra of $\mu$ Geminorum (Type III.) and 132 Schjellerup (Type IV.) are almost identical, while in the region slightly less refrangible there are many common lines. Further towards the red the spectra become very dissimilar, the strong flutings of carbon seen in 132 Schjellerup being entirely wanting in $\mu$ Geminorum, although there are a few common features sufficient for comparison. Other photographs in the region $H\beta$ to $H\gamma$ show similar coincidences. These photographs, it is stated, show a decided connection between the two classes of red stars, and the observation of more of them may bring out other links in their relationship.

## REMINISCENCES OF DARWIN—SIR JOSEPH D. HOOKER.

A STATUE of Charles Darwin by Mr. Hope Pinker, presented to the University of Oxford by Prof. Poulton, Hope Professor of Zoology, was unveiled at the University Museum on the 14th inst., and Sir Joseph D. Hooker delivered the following address, which we reprint from the *Times*, upon the occasion :—

The Vice-Chancellor of your University has done me the honour of asking me to address you on the occasion of the installation of the statue of the great naturalist which now adorns your museum, and has expressed his opinion that a few personal reminiscences would be more acceptable to you from me than an *éloge* of Mr. Darwin's researches and discoveries, of which latter indeed an excellent reasoned *résumé* is well known to you as the work of your Hope professor of zoology. In accepting the task of giving personal reminiscences, I am reminded of the fact that narrators of an advanced age are not only proverbially oblivious, but are too often the victims of self-deception in respect of what they think they remember, to which must be added that where a dual personification is attempted the narrator is apt to assume the more prominent position. I have thus many snares to avoid, and must hope for a lenient judgment on what follows.

### EARLY FRIENDSHIP WITH DARWIN.

The fact of our having commenced our scientific careers under very similar conditions favoured the rapid growth of a bond of friendship between Mr. Darwin and myself. We both of us, immediately after leaving our respective Universities, commenced active life as naturalists under the flag of the Royal Navy ; he as a volunteer eight years before me, who was an official. We both sailed round the world, collecting and observing often in the same regions, many of them at that time seldom visited and since made accessible to science by his researches—the Cape Verde Islands, St. Helena, Rio, the Cape of Good Hope, the Falkland Islands, Tierra del Fuego, Tasmania, and New Zealand. On returning to England we both enjoyed the rare advantage of the counsel and encouragement of one of the greatest leaders in science of the time—Mr., afterwards Sir Charles, Lyell. It was through the father of Sir C. Lyell, the translator of the "Vita Nuova" of Dante, and a friend of my father, that I first heard of Mr. Darwin. The "Journal of Researches into the Natural History and Geology of the Countries visited during the Voyage of the *Beagle*" was then passing through the press, and the proof sheets were being submitted to Sir C. Lyell for his information and criticisms. These were passed on to Sir Charles's father, himself a naturalist, who was permitted to lend them to me for perusal, because I was then preparing to accompany Sir James Ross as a naturalist on the Antarctic expedition (1839–43). At that particular time I was engaged upon engrossing hospital duties, and I slept with the proofs under my pillow that I might at once, on awaking, devour their contents. They impressed me profoundly, I may say despairingly, with the genius of the writer, the variety of his acquirements, the keenness of his powers of observation, and the lucidity of his descriptions. To follow in his footsteps, at however great a distance, seemed to be a hopeless aspiration ; nevertheless they quickened my enthusiasm in the desire to travel and observe. A copy of the complete work was a parting gift from Mr. Lyell on the eve of my leaving England, and no more instructive and inspiriting work occupied the bookshelf of my narrow quarters throughout the voyage. In the interval I had been introduced to Mr. Darwin, on a casual meeting in Trafalgar-square by a brother officer who had accompanied him in the *Beagle* to Rio, when I was impressed by his animated expression, heavy beetle brow, mellow voice, and delightfully frank and cordial greeting to his former shipmate. Shortly after the arrival in England of the Antarctic expedition (in 1843) I received from Mr. Darwin a long letter, warmly congratulating me on my return to my family and friends, directing my attention to the importance of correlating the flora of Fuegia with those of the Cordillera and of Europe, and inviting me to study and publish the botanical collections which he had made in the Galapagos Islands, Patagonia, and Fuegia.

### VISITS TO DARWIN AT DOWN.

This led to an interchange of views on the subject of geographical distribution, followed by an invitation to visit him at what he used to call his inaccessible home at Down, which was then eight or ten miles distant from the nearest railroad station. This I joyfully accepted ; and then commenced that friendship which ripened rapidly into feelings of esteem and reverence for his life, works, and character that were never clouded for one instant during the forty subsequent years of our joint lives. In the admirable biography of his father by my friend, Prof. Frank Darwin, are recorded the subjects, especially botanical and geographical, which were for many years the subjects of conversation and correspondence between us. During the many visits to Down which followed, he laid before me without reserve, not only his vast stores of knowledge, but his mature and immature speculations and theories, describing how they originated, and dwelling on their influence on the progress of his researches. Among these, so long ago as 1844, was his sketch of "The Origin of Species," which I was the first to see of the few friends to whom he ever showed it. At that very early period of my own studies I failed to grasp its full significance, *à propos* of which I may mention that I have been reproached for this by friends who have wondered, not only that I did not assimilate it at once, but that I did not apply it to my earliest essays on the distribution of plants. My friends overlooked the fact that the communication was a confidential one, of a hypothesis which its author hoped to establish as a tenable theory by an accumulation of facts in support of it, which he was engaged in collecting with a view to future publication. On the occasions of many other visits it was Mr. Darwin's practice to ask me, shortly after breakfast, to retire with him to his study for twenty minutes or so, when he brought out a long list of questions to put to me on the botanical subjects then engaging his attention. These questions were sometimes answered offhand, others required consideration, and others a protracted research in the Herbarium or in the gardens at Kew. The answers were written on slips of paper, which were deposited in bags or pockets that hung against the wall within

reach of his arm, each of them a receptacle devoted to a special object of inquiry. To me this operation of "pumping," as he called it, was most instructive. I could not but feel that any information that I could give him was comparatively trivial, while what I carried away was often as much as I could stagger under. As his health fluctuated or declined, and especially during his sharper attacks of illness, these interviews became intermittent, and on such occasions he would ask me to bring my own work with me to Down, where I pursued my studies free from the distractions of Kew, and with the advantages of his counsel and aid whenever desired. These morning interviews were followed by his taking a complete rest, for they always exhausted him, often producing a buzzing noise in the head, and sometimes what he called "stars in the eyes," the latter too often the prelude of an attack of violent eczema in the head, during which he was hardly recognisable. These attacks were followed by a period of what with him was the nearest approach to health, and always to activity. Shortly before lunch I used to hear his mellow voice under my window, summoning me to walk with him, first to inspect the experiments in his little plant-houses, and then to take a precise number of rounds of the "sand-walk," which he trudged with quick step, staff in hand, wearing a broad-brimmed straw hat and light shooting coat in summer, and a felt hat and warm cape in winter. This walk was repeated in the afternoon; on both these occasions his conversation was delightful, animated when he was well enough, never depressing however ill he might be. It turned naturally on the scenes we had witnessed in far-away regions and anecdotes of our seafaring lives, and on the discoveries in science, then, as now, hurrying onwards and treading on one another's heels in their haste for recognition. In the evening we had books and music, of which latter Mr. Darwin was, during the first few years of our friendship, almost passionately fond. I well remember now, at the 1847 meeting of the British Association in this city, his asking me to accompany him to hear the organ at New College Chapel, and, on coming away, saying to me, "Hooker, I felt it up and down my back;" and I find in the "Life and Letters" that when a student at Cambridge, after hearing a beautiful anthem, he made use of a similar expression to a friend who had accompanied him. It is a curious fact that music should have had in after life no charm for him—that "it set him thinking too energetically at what he had been at work on instead of giving him pleasure."

### An Estimate of Darwin's Character.

If I were asked what traits in Mr. Darwin's character appeared to me most remarkable during the many exercises of his intellect that I was privileged to bear witness to, they would be, first, his self-control and indomitable perseverance under bodily suffering, then his ready grasp of difficult problems, and, lastly, the power of turning to account the waste observations, failures, and even the blunders of his predecessors in whatever subject of inquiry. It was this power of utilising the vain efforts of others which in my friend Sir James Paget's opinion afforded the best evidence of Darwin's genius. Like so many men who have been great discoverers, or whose works or writings are proofs of their having intellects indicating great originality, he was wont to attribute his success to industry rather than ability. "It is dogged that does it" was an expression he often made use of. In his autobiography he says of himself, "My industry has been nearly as great as it could have been in the observation and collection of facts"; and, again, "of the complex and diversified mental qualities and conditions which determined my success as a man of science, I regard as the most important the love of science—unbounded patience in long reflecting over many subjects—industry in observing facts, and a fair share of invention, as well as of common sense." In this introspection he has, if my judgment is correct, greatly undervalued "invention"; that is originality or that outcome of the exercise of the imagination which is so conspicuous in every experiment he made or controlled, and in the genesis of every new fact or idea that he first brought to light. Referring to his disregard when possible of his bodily sufferings, I remember his once saying to me that his sleepless nights had their advantages, for they enabled him to forget his hours of misery when recording the movement of his beloved plants from dark to dawn and daybreak. For those other qualities of head and heart that endeared Mr. Darwin to his friends I must refer you to the "Life and Letters." There is only one upon which I would comment, it is that passage of his autobiography where he says, "I have no great quickness of apprehension or wit." Possibly the "of" and "or" are here transposed; whether or no, my impression of his conversation has left the opposite as characteristic of him. It is, at any rate, inconsistent with the fact that in arguing he was ever ready with repartee, as I many times experienced to my discomfiture, though never to my displeasure; it was a physic so thoughtfully and kindly exhibited. And I may conclude these fragmentary records with an anecdote which goes, I think, to support my view, and which I give, if not verbally correctly, as nearly as my memory of so ancient an episode permits. I was describing to him the reception at the Linnean Society, where he was unable to be present, of his now famous account of "The two forms or dimorphic condition of Primula," for which he took the common primrose as an illustration. On that occasion an enthusiastic admirer of its author got up, and in concluding his *éloge* likened British botanists who had overlooked so conspicuous and beautiful a contrivance to effect cross-fertilisation to Wordsworth's "Peter Bell," to whom

> "A primrose on the river's brim
> A yellow primrose was to him,
> And it was nothing more."

When I told Mr. Darwin of this he roared with laughter, and, slapping his side with his hand, a rather common trick with him when excited, he said, "I would rather be the man who thought of that on the spur of the moment than have written the paper that suggested it."

## "*AMERIND*"—*A SUGGESTED DESIGNATION FOR AMERICAN ABORIGINES.*

A PART of the *Proceedings* of the Anthropological Society of Washington, at a meeting on May 23, seem destined to produce permanent influence on ethnologic nomenclature; this part of the proceedings taking the form of a symposium on the name of the native American tribes. The discussion was opened by Colonel F. F. Hilder, of the Bureau of American Ethnology, with a critical account of the origin of the misnomer "Indian," applied by Columbus to the American aborigines; he was followed by Major J. W. Powell, who advocated the substitution of the name *Amerind*, recently suggested in a conference with lexicographers. A communication by Dr. O. T. Mason followed, in which the various schemes of ethnologic classification and nomenclature were summarised and discussed. Contributions to the symposium were made also by Dr. Albert S. Gatschet, Dr. Thomas Wilson, and Miss Alice C. Fletcher. At the close of the discussion the contributions were summarised by President McGee as follows:—

(1) There is no satisfactory denotive term in use to designate the native American tribes. Most biologists and many ethnologists employ the term "American"; but this term is inappropriate, in that it connotes, and is commonly used for, the present predominantly Caucasian population. The term "Indian" is used in popular speech and writing, and to a slight extent in ethnologic literature; but it is seriously objectionable in that it perpetuates an error, and for the further reason that it connotes, and so confuses, distinct peoples. Various descriptive or connotive terms are also in use, such as "North American Savages," "Red Men," &c.; but these designations are often misleading, and never adapted to convenient employment in a denotive way.

(2) In most cases, the classifications on which current nomenclature are based, and many terms depending on them for definition, are obsolete; and the retention of the unsuitable nomenclature of the past tends to perpetuate misleading classifications.

(3) While the name "Indian" is firmly fixed in American literature and speech, and must long retain its current meaning (at least as a synonym), the need of scientific students for a definite designation is such that any suitable term acceptable to ethnologists may be expected to come into use with considerable rapidity. In this, as in other respects, the body of working specialists form the court of last appeal; and it cannot be doubted that their decision will eventually be adopted by thinkers along other lines.

(4) As the most active students of the native American tribes, it would seem to be incumbent on American ethnologists to propose a general designation for these tribes.

(5) In view of these and other considerations, the name *Amerind* is commended to the consideration of American and foreign students of tribes and peoples. The term is an arbitrary compound of the leading syllables of the frequently-used phrase "American Indian"; it thus carries a connotive or associative element which will serve explicative and mnemonic function in early use, yet must tend to disappear as the name becomes denotive through habitual use.

(6) The proposed term carries no implication of classific relation, raises no mooted question concerning the origin or distribution of races, and perpetuates no obsolete idea; so far as the facts and theories of ethnology are concerned, it is purely denotive.

(7) The proposed term is sufficiently brief and euphonious for all practical purposes, not only in the English, but in the prevailing languages of continental Europe; and it may readily be pluralised in these languages, in accordance with their respective rules, without losing its distinctive sematic character. Moreover, it lends itself readily to adjectival termination in two forms (a desideratum in widely-used ethnologic terms, as experience has shown), viz. *Amerindian* and *Amerindic*, and is susceptible, also, of adverbial termination, while it can readily be used in the requisite actional form, *Amerindise*, or in relational form, such as *post-Amerindian*, &c.; the affixes being, of course, modifiable according to the rules of the different languages in which the term may be used.

(8) The term is proposed as a designation for all of the aboriginal tribes of the American continent and adjacent islands, including the Eskimo.

The working ethnologists in the Society were practically unanimous in approving the term for tentative adoption, and for commendation to fellow-students in this and other countries.

## MAGNETIC OBSERVATIONS AT MAURITIUS.[1]

DR. MELDRUM'S name is inseparably connected with the fortunes of the Royal Alfred Observatory. The value of his researches in meteorology, especially in cyclonic movements of the atmosphere, has been repeatedly acknowledged. The simple rules that he has enunciated for the handling of ships during hurricanes in the Southern Seas are based upon rigorous scientific grounds, and though it may be true that no completely satisfactory rule is possible for determining more than the approximate position of the central vortex of a cyclone by any observations at a single station, yet in a majority of cases the mariner who trusts strictly to the instructions provided will find himself in a position of safety. The recent publication of the Mauritius magnetic reductions by Mr. Claxton, the present director of the Royal Alfred Observatory, shows that Dr. Meldrum devoted himself not less energetically to the study of the absolute determinations of the magnetic elements of his station. We may never arrive at the happy condition foreshadowed by Gauss, when trustworthy and complete observations from all parts of the earth shall be obtained, but the possession of a continuous record from a distant outlying station has a value peculiarly its own, and may act as a stimulus to the establishment of other observatories in localities where they are most needed to provide material for the discussion of the amount of change in the magnetic potential of the earth, of which the simultaneous magnetic disturbances afford evidence.

Mr. Claxton, with a loyalty which we recognise and appreciate, is content to stand aside and play the part of editor to his predecessor's work. But the arrangement is not very satisfactory, giving rise as it does to two introductions, one by the editor and one by Dr. Meldrum. If the information derivable from these two sources had been carefully welded into one consecutive history, the description of the tables could have been followed more easily, and the processes employed in the reductions have been more readily apprehended.

The general arrangement does not call for any special remark. All who have been engaged in similar work know the amount of labour involved, and the care that has to be exercised. We notice what we think is a very praiseworthy feature, a determined effort to maintain a uniformity of sensitiveness on the photographic record. A difference of one m.m. in the scale reading is intended to represent a scale value of ·0005 millimetre-milligramme. This is a convenient value, sufficiently sensitive to exhibit changes for ordinary magnetic disturbances, but yet not so sensitive as to send the spot of light off the paper even in a violent magnetic storm. But Dr. Meldrum reports that it is impossible in spite of every precaution to keep this value of the coefficient constant. The length of time elapsed between the cleaning of the knife edge and the agate plane, the temperature, the change of level of the magnet due to secular decrease in the value of the vertical force, all operate as disturbing causes, necessitating continual examination and readjustment. Tables of the scale coefficient employed are given. The horizontal force magnet shows as usual the larger variation.

Mr. Claxton gives in a tabular form the more trustworthy determinations of declination and dip that have been made on the island of Mauritius since 1750. Lacaille gave 52° 55′ for inclination in 1761, and in 1896 this angle had increased to 54° 32′. The earliest determination of declination gave 16° 30′ W. in 1753, it now reads 9° 49′; but the director points out, which indeed is sufficiently obvious, that there are large discrepancies among the observations arising probably from the use of indifferent instruments and the effect of local magnetic attraction, varying at the different spots at which the several determinations have been made. For these reasons, no attempt has been made to discuss the secular variation of any of the magnetic elements.

[1] "Mauritius Magnetical Reductions." Edited by T. F. Claxton, F.R.A.S. Being a discussion of the results obtained from the self-recording magnetometers from 1875 to 1890, under the direction of C. Meldrum, M.A., LL.D., F.R.S.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—In a congregation held on June 13 the Curators of the University Chest were authorised to expend a sum not exceeding 10,000*l.* in the erection of a pathological laboratory on ground adjoining the University Museum, and also to pay the sum of 250*l.* a year for five years for the equipment and maintenance of this laboratory from the date at which it shall be brought into use. An anonymous donor, a member of the University, has already offered the sum of 5000*l.* towards the erection of this laboratory, provided that it be commenced before January 1, 1901.

The above decrees were passed by Convocation on June 20, when also the twenty-fourth annual report of the visitors of the University Observatory was presented. In consequence of this report, the Curators of the University Chest will be asked to expend a sum not exceeding 500*l.* in the reconstruction of the western dome of the observatory.

It is proposed to adapt the upper floor of the Ashmolean Museum for the purposes of instruction in geography.

CAMBRIDGE.—At St. John's College the following awards in Natural Science were made on June 19:—

Foundation Scholarships continued or increased: Rudge, Yapp, Howard, Brown, Harnett, Lewton-Brain, O. May, Adams, Fletcher, Harding, Browning, Gregory, Wakely, Williams, Walker.

Exhibitions: Wyeth, Ticehurst, J. H. Field, King, Paton.

Hutchinson Studentship for research (botany and zoology): G. S. West.

Research Prize (physics): Vincent.

Herschel Prize (astronomy): Eckhardt.

A CORRESPONDENT informs us that Mr. G. Birtwistle, who was bracketed Senior Wrangler this year with Mr. R. P. Paranjpye, has not only had much success in mathematics during his career, but has distinguished himself in other subjects. When at Owens College he devoted himself chiefly to chemistry, and in 1896 graduated B.Sc. with first-class honours in chemistry, obtaining also a Le Blanc medal and University scholarship. With regard to Mr. Paranjpye, the Allahabad correspondent of the *Times* states that he is a Maratha Brahmin, born twenty-three years ago in the village of Murdi, in the Ratnagiri district. First in the first division has been his invariable record since in 1891, at the age of fifteen, he headed the list at the matriculation examination for the whole of the Bombay Presidency. During his three years at Fergusson College he passed first in the first class at every examination. Fergusson College is an institution manned entirely by native professors, and Mr. Paranjpye, before going to England, pledged twenty years of his life to service in the college, where he will draw a salary not exceeding Rs.70 a month.

THE quinquennial meeting and international congress convened by the International Council of Women will be held in London on June 26–July 5. A number of subjects in the progress of which women take active part will be discussed in the various sections of the congress. In the educational section the life and training of the child, primary education, universities, modern educational experiments, technical education, women as educators, co-education, training of teachers, and examinations, will be brought forward. In the professional section, among the subjects of papers and discussions are: professions open to women, and the work of women in physical and biological sciences. Other subjects to be discussed are farming in its various branches as an occupation for women, and the training of women in agriculture, horticulture, and other trades and professions.

IN an address delivered at the Leys School, Cambridge, on Friday last, Mr. A. J. Balfour referred to the educational values of science and literature. In the course of his remarks he said: "I cannot really conceive that any man, however enamoured of scientific method, should for a moment undervalue that insight into human nature and the interests which have always stirred human nature, and the manner in which those interests have been transformed by men of genius from time to time in the imaginative crucible of literature—I cannot imagine that such a training should be undervalued even by the most rigid advocate of scientific method. On the other hand, is it credible that in these days there should any man be found who should undervalue that curiosity about the world in which we live which science cannot indeed satisfy, but towards the satisfaction of which, after all, science is the only minister?" The claims of science are here given fair recognition, and men of science do not usually ask for more than this. Their complaint is that science is too often regarded as the Cinderella among school and university subjects; and it is only of late years that any noteworthy improvements have taken place in her position.

AN interesting account of the "Mosque of the Olive Tree" (Jama-Ez-Zituna) at Tunis, one of the three great centres of Mahomedan learning in North Africa, the others being El Azhar in Cairo and the Great Mosque at Fez, in Morocco, is given in a recent report by Sir Harry Johnston. Over 400 students are usually taught at this University, while there are about 100 professors. The lectures begin at sunrise and continue until sunset, fifteen different lectures usually going on at the same time. Each professor sits cross-legged, with his back against one of the many columns of the mosque, his students grouped about him. Until recently, there was but little method in the instruction; each professor rambled on in his discourse, ranging over any topic on which he cared to impart information, and the students listened or not as they chose. To encourage a more practical education, the State offered the students exemption from military service and from certain taxes if they passed an elementary outside examination; but only four of sixty-six recently succeeded in doing this. In future, it is intended to impress on the management of the mosque that each professor should keep to one subject; that the student should be obliged to take notes, and pass periodical examinations. External lectures on scientific subjects and on matters of present-day interest have also been established, and about 100 students from the mosque now attend these.

## *SOCIETIES AND ACADEMIES.*

### LONDON.

**Royal Society**, April 27.—"On the Presence of Oxygen in the Atmospheres of certain Fixed Stars." By David Gill, C.B., F.R.S., &c., Her Majesty's Astronomer at the Cape of Good Hope.

The observations described confirm the conclusions arrived at by Mr. F. McClean and Sir Norman Lockyer as to the existence of oxygen lines in the spectrum of $\beta$ Crucis. From measures of photographs of the spectrum of this star, it is concluded that the whole of the known helium lines within the measured range of spectrum are unquestionably present, as also are all known oxygen lines stronger than intensity 4.

"There remains not the slightest doubt that all the stronger oxygen lines are present in the spectrum of $\beta$ Crucis, at least between $\lambda$ 4250 and 4575, and this fact requires no further aboratory experiments for its establishment. It is almost equally certain that there is no trace of true nitrogen lines in this spectrum. . . . Besides hydrogen, helium and oxygen, the spectrum of $\beta$ Crucis shows the probable presence of carbon (4267·2) and magnesium (4481·17). . . . The spectra of $\beta$ Crucis, $\beta$ and $\epsilon$ Canis Majoris, and probably $\beta$ Centauri are all practically identical."

**Linnean Society**, June 1.—Dr. A. Günther, F.R.S., President, in the chair.—Mr. W. B. Hemsley, F.R.S., exhibited a selection of high-level plants from the collections formerly made by Sir Joseph Hooker, Dr. Thomson, General Sir R. Strachey, and more recently by Captain Welby, Mr. and Mrs. Littledale, and Mr. Arnold Pike in Northern India, Tibet, and Mongolia, many of them from altitudes of 18,000 to 19,200 feet. A selection was also shown from the collections made in the Andes by Sir Martin Conway, Mr. Fitzgerald, Mr. Gosse, and Mr. Whymper, at various altitudes up to 18,500 feet. The principal points referred to were the small size of many of the plants, the protective woolly covering of others, and the general preponderance of the natural order *Compositae*.—On behalf of Mr. Rupert Vallentin, Mr. J. E. Harting exhibited lantern slides of the so-called "Sea-Elephant" (*Macrorhinus elephantinus*), prepared from photographs taken in February last by Mr. Vallentin in the Falkland Islands. After briefly tracing the distribution of this huge seal on various Antarctic and subtropical islands, Mr. Vallentin's notes on a specimen killed in Stanley Harbour were read. This specimen measured 18 feet 11 inches from the end of the trunk to a straight line between the two hinder extremities; the trunk, produced by the inflation of a loose tubular sac of skin above the nostrils, is present only in the male, and measures, when fully extended, twelve inches from the gape. No fresh facts were made known concerning the nature of the food of this animal, described by some writers as herbivorous like the manatee, by others as feeding on mollusca and crustacea like the walrus. In this case the stomach was empty, with the exception of a large number of Nematode worms, specimens of which were exhibited.—Mr. Harting also exhibited and made remarks on some living specimens of the Bank vole (*Microtus glareolus*), recently obtained by Mr. Robert Drane on Skomer Island, Pembrokeshire.—Mr A. W. Bennett exhibited and described a remarkable Alga from Scotland (*Lyngbya* sp. ?) possessing a soluble pigment producing a beautiful fluorescent solution.—The President exhibited photographs of four out of eight gigantic tortoises originally brought from Aldabra Island, and now living in the grounds of Government House, Seychelles, and communicated a report on the subject of the present distribution of the species, addressed to the Right Hon. Joseph Chamberlain, M.P., by the Administrator of the Seychelles.—Sir John Lubbock, Bart., M.P., F.R.S., read a paper on some Australasian collembola, figures of which were exhibited.—On behalf of Mr. F. N. Williams, the Secretary read a paper on some *Caryophyllaceae* from Szechuen, with a note on the recent botanical exploration of that province.—A paper was read by Mr. W. T. Calman on the Crustacean genus *Bathynella* (Vejd.), which was shown to be an ally of the important form *Anaspides* (Thom.) originally described in the Society's *Transactions*, vol. vi. p. 285.

**Zoological Society**, June 6.—Dr. Henry Woodward, F.R.S., Vice-President, in the chair.—Mr. Sclater exhibited photographs of the female specimen of Grévy's zebra now living in the gardens of the Société d'Acclimatation, Paris; and read a letter from Captain J. L. Harrington, H.B.M. Envoy to Abyssinia, in which he expressed a hope to be able to bring living examples of this animal home with him when he returned to this country.—Mr. A. Blaynay Percival exhibited and made remarks upon some specimens of birds and insects which he had recently brought from the southern districts of British Central Africa.—Mr. G. A. Boulenger, F.R.S., exhibited some living specimens of a Siluroid fish, the "Harmut" (*Clarias lazera*, C and V.), from Damietta, Egypt, collected by Mr. W. L. S. Loat, which were believed to be the first examples of this curious fish imported alive to this country.—Dr. S. F. Harmer, F.R.S., gave an account of specimens of the remains of a deer in the collection of the University Museum of Zoology at Cambridge, obtained from the Forest-Bed series at Pakefield, near Lowestoft, and belonging to the form usually known as *Cervus verticornis*, Dawk. The cranial portion of the skull was well preserved, and the antlers had a spread of six feet, measured in a straight line. The question of nomenclature was considered, with the result that *C. verticornis* of the Forest-

Bed was shown to be, probably, not identical with *C. carnutorum*, Laug., but a synonym of *C. belgrandi*, Lart.—Dr. A. Günther, F.R.S., gave an account of a collection of freshwater fishes made by Mr. R. B. N. Walker in the rivers of the Gold Coast. The collection, though a small one, was of considerable interest, as it contained specimens of several forms previously unknown from the Gold Coast. It had led the author to prepare a critical revision of the Gaboon species of *Chrysichthys*, which were numerous and difficult of discrimination. Eight new species were described in this paper, viz. *Petersius occidentalis* and seven species of *Chrysichthys*.—A communication was read from Dr. R. O. Cunningham, containing notes on the structure of Laborde's shark (*Euprotomicrus labordii*), an example of which had recently been presented to the museum of Queen's College, Belfast.—A communication was read from Mr. J. Stanley Gardiner, containing an account of the Astræid corals which he had collected in the South Pacific. The collection contained specimens of twelve genera and forty-eight species, six of the latter being new to science.—A communication was read from Dr. W. T. Blanford, F.R.S., containing the characters of several species of shells of the genera *Streptaxis* and *Ennea* from India, Ceylon and Burma. Of the former genus three species were described as new, bringing up the number of species of this genus, described from Southern India, to eleven. Of the genus *Ennea* two new species were described.

**Mathematical Society**, June 8.—Lord Kelvin, G.C.V.O., President, in the chair.—The President announced that the Council had awarded the De Morgan medal to Prof. W. Burnside, F.R.S., for his researches in mathematics, particularly in the theory of groups of finite order. Prof. Burnside, who was present, briefly returned thanks for the award, which had taken him by surprise.—Prof. Mittag Leffler, of Stockholm, a foreign member, was admitted into the Society, and made an interesting communication (in French) on the convergency of series. Prof. Elliott, F.R.S., Prof. Love, F.R.S., and Dr. Hobson, F.R.S., offered some remarks, to which Prof. Mittag Leffler replied.—The President spoke on "Solitary waves, equivoluminal and irrotational, in an elastic solid." In the course of his address he showed how greatly mathematicians were indebted to Sir George Stokes, F.R.S. Prof. Love said he had been much interested in the diagrams shown by Lord Kelvin. He afterwards gave a sketch of a paper by Prof. J. H. Michell on the transmission of stress across a plane of discontinuity in an isotropic elastic solid, and the potential solutions for a plane boundary.—The following papers were taken as read: On several classes of simple groups, Dr. G. A. Miller; on theta differential equations and expansions, Rev. M. M. U. Wilkinson; finite current sheets, Mr. J. H. Jeans; (1) on a congruence theorem having reference to an extensive class of coefficients; (2) on a set of coefficients analogous to the Eulerian numbers, Dr. Glaisher, F.R.S.; (1) the reduction of a linear substitution to its canonical form; (2) on the integration of systems of total differential equations, Prof. A. C. Dixon.

**Entomological Society**, June 7.—Mr. G. Verrall, President, in the chair.—Mr. J. J. Walker exhibited on behalf of Mr. G. F. Mathew a number of interesting Lepidoptera, chiefly from the Mediterranean region, and including amongst others the following: examples of *Thais polyxena*, Schiff., var. *ochracea*, Staud., having an unusually deep and rich colour, bred from larvæ found at Platæa, Greece; male and female of *Thestor ballus*, Hb., from Alexandria, the male remarkable in being largely marked with orange on the upper side of the front wings; and a singular aberration, from Corfu, of *Melitaea didyma*, Ochs., with central band of black spots very strongly marked on both wings, the other spots being obsolete and the ground colour pale fulvous.—Mr. E. E. Green exhibited a teratomorphic specimen of a zygænid moth, *Chalcosia venosa*, Walk., which he had found at rest on a leaf in Ceylon. In this specimen four wings were present on the left side, the hindmost being almost as fully developed as the normal hind wing on the right side, while the other three appeared to be attached to the meso-thorax. He also showed larvæ and pupæ of insects in air-tight glass tubes in which a little cotton wool, sprinkled with formalin, had been placed. The specimens, which had been thus preserved for nearly two years, had lost little of their original colour or brilliancy.—Mr. Gahan exhibited pupa-cases of a Longicorn beetle, *Plocederus obesus*, Gah., which were remarkable in being composed almost wholly of carbonate of lime. It was not known how the pupa-cases were fabricated, but presumably the larvæ must possess special lime-secreting glands.—Mr. R. McLachlan read a paper on a second Asiatic species of *Corydalis*, and exhibited the male type of the species described, which he proposed to name *Corydalis orientalis*. He said the first Asiatic species of *Corydalis* was described and figured by Prof. Wood-Mason in 1884, the genus up to that time having been considered to be peculiarly American. Mr. H. J. Elwes communicated a paper on the Lepidoptera of the Altai Mountains, and the Rev. A. E. Eaton a paper entitled "An annotated list of the *Ephemeridae* of New Zealand."

**Geological Society**, June 7.—W. Whitaker, F.R.S., President, in the chair.—On the geology of Northern Anglesey, by C. A. Matley; with an appendix on the microscopic study of some of the rocks, by Prof. W. W. Watts. The strata which occupy the northern part of Anglesey have been the subject of much controversy, some geologists considering them (with the exception of a few patches in the extreme north) to be pre-Cambrian, while others maintain that they are of Bala age, and that they are an upward continuation of the black slates that everywhere appear to underlie them to the south. The author attacks this problem from its palæontological as well as its stratigraphical side. The contortion, overfolding, cleavage, dislocation, and disruption which the rocks have undergone are described. Disruption is traced from its early stages into "crush-conglomerates." Some of the disrupted rocks are Ordovician, and traces of ancient dykes have been found rent to pieces by the movement, which is stated to be post-Ordovician and pre-Carboniferous. The detached masses of limestone and the isolated "quartz-knobs" of the northern complex are considered to be portions of strata which have suffered disruption in the same way as the thinner hard bands in the crush-zones. The appendix contains notes on some of the rocks from the Green series and the Ordovician system, the quartzites, and the crush-conglomerates.—On an intrusion of granite into diabase at Sorel Point (Northern Jersey), by John Parkinson. In the early pages the general character of this intrusion is described. Following this general introduction, the characters of the granite are described in some detail; then those of the diabase, formerly an ophitic dolerite. Details of structure of the granite in which absorbed basic material is present, and of the diabase into which acid material has permeated, are dealt with: particular attention being directed to the great alteration which the diabase has undergone—this has frequently amounted to a total reconstitution. In conclusion, points of resemblance and of difference are noted between this district and others; and an interesting slide from Alderney is described, showing the probable extension of such rocks in other directions.

EDINBURGH.

**Royal Society**, May 8.—Prof. Flint in the chair.—By request of the Council, Mr. C. W. Andrews, of the British Museum, gave an account of his expedition to Christmas Island, with special reference to its geology. The island seems to be a raised atoll resting on a basis of volcanic rocks and Miocene limestones, which in places are some hundreds of feet thick. The rocks forming the highest parts of the island are for the most part dolomitised, and the most recent of the deposits found are beds of phosphate of lime, which cap some of the highest hills on the east and north sides. Formerly existing as a group of islets with a central lagoon, Christmas Island has undergone a succession of movements of elevation, evidenced by the existence of a number of inland cliffs and terraces. At present a narrow fringing reef is forming round the greater part of the coast. The fauna and flora are specially remarkable for the large number of species peculiar to the island. Specially interesting are the two forms of rats (the one being fitted for climbing trees, and the other for burrowing), six species of land-crab, two bats (one flying at midday), several forms of pigeon, and numerous sea birds. As regards the flora, there was no difficulty in understanding how the seeds had originally found a lodgment in the island. One important part of the work of the expedition was to make a collection of the fauna and flora before the settlement of the island led to the introduction of foreign species and the modification or destruction of the endemic forms. Sir John Murray, in emphasising the importance of the scientific work carried out by Mr. Andrews, pointed out that Christmas Island was an illustration of how unexpectedly purely scientific inquiry led to a practical issue; for it was in the course of his investigations

into oceanic deposits that he discovered Christmas Island to be a storehouse of phosphate of lime.

May 16.—Prof. McKendrick in the chair.—Dr. C. G. Knott gave a short note on magnetic strains in bismuth. A slight indication had been obtained that there was a change of form in bismuth when strongly magnetised, but the indication was so slight that it was more prudent meanwhile to reserve judgment. —A communication by Mr. Omond on fog-bows, &c., seen at Ben Nevis since 1887, and a note on fog-bows by Prof. Tait were presented in continuation of former papers.—Mr. R. Forgan exhibited his practical method of enlarging and deepening the field of a compound microscope. The essence of the method consisted in shortening the distance between the object-glass and eye-piece, thereby obtaining a diminution of magnification with a corresponding increase of field. In short, the microscope was made to act somewhat after the fashion of a telescope. One interesting feature was the remarkable depth of focus obtained, so that the florets of a dandelion head could be seen throughout with great distinctness. The Chairman remarked that the form of microscope exhibited should prove very serviceable in the study of circulatory systems when high magnification was not desired.—The Rev. Prof. Duns, in a paper on some remains of Scottish early Post-Pliocene mammals, drew attention to the very important problems—zoological, climatological, and ethnographical—which were associated with the disappearance of animals in recent times. For example, what causes led to the disappearance of certain species, among whose remains no contemporaneous human remains were found? Did the absence of human remains necessarily imply that man had not appeared on the scene? The problems should be looked at both from the biotic and stratigraphical points of view; and it was most desirable that, in their characterisation of extinct species, experts should include a description of the physical and vital conditions of the localities in which these species occurred. The paper included a history and description of the fine mammoth tusk discovered near Ratho, Midlothian, in 1820, of the magnificent Greater Red Deer antlers discovered near Kingskettle, Fife, and other important relics now in the museum of the Free Church College, Edinburgh.

PARIS.

Academy of Sciences, June 12.—M. van Tieghem in the chair.—The jubilee of Sir G. G. Stokes and the centenary of the Royal Institution, by M. A. Cornu.—The angle of inclination of the sides studied with the aid of radioscopy and radiography both in morbid and healthy states, by MM. Ch. Gouchard and H. Guilleminot. The authors have studied more especially the appearances in cases of pleurisy. In recent unilateral pleurisy the diseased side has a smaller amplitude of oscillation than the healthy one, and the side is inclined at a greater angle.—Observations of shooting-stars, made at Athens, by M. D. Eginitis. The observations refer especially to the swarms observed on the nights of October 17, 18, November 3, 8, and 25, and December 6, 7, 11, 12, and 13.—On an extension of a theorem of Mittag-Leffler, by M. E. Phragmén. —Deformation of waves in the course of propagation, by M. P. Vieille.—On the equation of motion of automobiles, by M. A. Blondel.—Trials of instruments destined for experiments on the decimalisation of angles, by M. Caspari.—On the expansion of metallic alloys, by M. H. Le Chatelier. Alloys of copper and antimony, and copper with aluminium were studied, and the results expressed graphically in two curves.—The direct measurement of the osmotic pressure of very dilute solutions of sodium chloride, by M. A. Ponsot. The values found for the coefficient $i$ varied between 1·76 and 1·81, agreeing closely with the results obtained by Pickering by the freezing point method.—Rays emitted by an electrified point, by M. S. Leduc. The rays given off from a point connected with an electrostatic machine resemble the violet rays of the spectrum in their effects upon a sensitised plate.—Heat of oxidation of sodium, by M. de Forcrand. From the data given it would appear that the number currently admitted for the heat of oxidisation of sodium is too high by about 10 per cent.—On the estimation of hydrogen phosphide in gaseous mixtures, by M. J. Riban. A criticism of a recent paper by M. Joannis. The author contends that an acid solution of cuprous chloride acts perfectly satisfactorily as an absorbent for phosphoretted hydrogen, provided that care be taken to use an unoxidised product.—Action of iodine on alkalies, by M. E. Péchard.—Action of water upon the double iodides of mercury with potassium and ammonium, by M. Maurice François.—On copper reduced at low temperature, by M. Alb. Colson. Copper oxide reduced at 200° by hydrogen or by carbon monoxide, gives many reactions that do not occur with copper foil. Thus the metal catches fire in dry bromine, even at −21° C. If the copper is raised to above 280° C., or if exposed to moist air, it loses this property.—On mixed anhydrides of formic acid, by M. A. Béhal. By mixing formic acid and acetic anhydride, heat is evolved, and the cause of this is attributed by the author to the formation of a mixed anhydride, $CH_3.CO.O.CHO$, which can be isolated by treatment with petroleum ether and fractional distillation.—Contribution to the study of ivy; preparation of hederine, by M. Houdas. The glucoside hederine, $C_{64}H_{104}O_{19}$, obtained from ivy, gives on hydrolysis by dilute acids, rhamnose, a new sugar hederose, and a new substance $C_{26}H_{40}O_4$, to which the name of hederidine is given.—On the form *Oospora* (*Streptothrix*) of the *Microsporum* of the horse, by M. E. Bodin.—On a layer of magnetite with granite at Quérigut (Ariège), by M. A. Lacroix.—On the presence of iodine in the mineral waters of Royat, by M. A. Duboin. Iodine was not present in solution, but only in traces in organic compounds in suspension, ·04 mgr. iodine in 1 litre of water.—Bathymetric map of the Azores, by M. J. Thoulet.—Nervous oscillations following unipolar excitation; method for measuring their speed of propagation, by M. Aug. Charpentier.—Ivy and hederine; physiological and toxicological study, by M. A. Joanin.—New researches on the diastatic functions of indigo-bearing plants, by M. L. Bréaudat.—On a parasitic fungus in cancer, by M. J. Chevalier. A comparison of the organism isolated by the author, with that isolated previously from cancer growths by Dr. Bra, showed that the two parasites were absolutely identical.

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THURSDAY, JUNE 29, 1899.

## PETTIGREW ON THE LOCOMOTIVE.

*A Manual of Locomotive Engineering*. By William Frank Pettigrew, M.Inst.C.E.; with a selection of American and Continental Engines, by Albert F. Ravenshear, B.Sc., Whit. Sch. Pp. 430. (London: Charles Griffin and Co., Ltd., 1899.)

IT is with much pleasure we welcome this valuable addition to the literature of locomotive engineering—a subject seldom dealt with in text-books, and one which depends more on the results of experience than on theory as usually set forth in our technical schools. An author, therefore, in a position to deal with the subject in a satisfactory manner must of necessity have had a railway experience of no ordinary kind. In fact he must have gone through the mill in the form of the shops, works-management, and finally as locomotive superintendent. The author of this volume fills these requirements exactly, consequently we are not disappointed with his work.

In a volume consisting of about 400 pages we find the subject carefully treated, and divided into twenty-two chapters with three appendices. To commence with, we naturally find the pioneer forms of locomotives historically dealt with, and this is as it should be from the student's point of view; the credit, however, for earlier successes does not always appear to be given to the proper parties. The "Rocket," for instance, was a success mainly because of the multitubular boiler patented by William Henry James, and adopted by Stephenson in consideration of one-fourth share of the patent obtained by Losh and Stephenson for locomotive engines. The progress of earlier locomotives in the United States is also described—a very interesting subject when one remembers that "Old Iron Sides" was built by W. Baldwin in 1832, this maker being represented to-day by the eminent firm of the same name in Philadelphia.

On the subject of modern simple locomotives the author has a wealth of material at hand, that is to say, on single expansion engines. In Chapter ii., dealing with this branch of the work, we find a cursory definition of wheel-base, engine power, tractive force, boiler power, &c. (all of which are exhaustively treated later on in the work), after which very full and excellent descriptions of modern practice are given. The famous "Dunalastair" of the Caledonian Railway is mentioned; but more should have been said of this engine, for Mr. J. F. McIntosh, the able locomotive superintendent of that railway, is certainly the prophet of the big boiler in this country, and deserves mention for this reason. Other Scotch engines are described, including those of the Highland Railway, the illustrations of which do not include the louvres in the chimneys, "a fatal oversight." As an example of the older practice on the Manchester, Sheffield and Lincolnshire Railway, we find Mr. Charles Sacre's single express engine; we should have preferred the double-framed four-coupled bogie as a record of this eminent locomotive engineer. But why does the author omit the present practice on the Manchester, Sheffield and Lincolnshire, or rather the Great Central Railway, an example of which would have been interesting?

Chapter iii. deals with compound locomotives, and very fully does the author describe the various systems in vogue. Here this type of locomotive is uncommon, except on the North-Western Railway, where the Webb system is in use. Many experiments have been made on different railroads, but nearly all have returned to the simple type for express work, although for heavy goods traffic the Worsdell system is in use on the North-Eastern Railway.

On primary considerations of locomotive design we find much useful information, more particularly on train resistance, the author maintaining that the older formulæ are not sufficiently accurate, due to various causes, and proposes one which agrees fairly with practice, viz. $R = 9 + \cdot 007\ V^2$, where R is the resistance in pounds per ton, and V the speed in miles per hour. On the question of proportionate heating surface the author gives minimum values, and goes on to say, get as much as the design will allow. This is no doubt the right view to take, and locomotive engineers in this country are waking up to the fact that the bigger the boiler the more satisfactory the engine.

The author having been the works manager in the Nine Elms Works of the London and South-Western Railway Company for many years, one naturally expects to find all the detailed descriptions of parts of a locomotive very practical and concise. In Chapter v., dealing with cylinders and their parts, this expectation is fulfilled. A useful addition would be to add a simple test for cylinder metal, such as a tensile test of, say, 11 tons per square inch, or the regular shearing test of a 2-inch by 1-inch bar on supports 3 feet apart, to deflect three-tenths of an inch with a breaking load of not less than 35 cwt.

The conical form of piston-head shown in Fig. 69 was adopted by the late Mr. Stroudley to enable him to get as long a connecting rod as possible, and was usually made of gun-metal for the express engines. Many piston-heads are running made of wrought iron, a fact which the author fails to mention.

The descriptions of the arrangement of single and double slide bars are good, but we fail to read that the arrangement with four bars in Fig. 81 is the best when considered from the standpoint of weight of moving parts and balancing them. Further on, our author deals with connecting and coupling rods of various designs. Generally we find very little information as to the material used for these important details, and where steel is mentioned no tensile tests are given.

Chapter ix. deals with the important question of balancing the moving parts of a locomotive when in motion, and we must cordially congratulate Mr. Pettigrew on the very clear manner he has handled this important subject. The examples given are clear, and are worked out without unnecessary use of higher mathematics.

Valve gear, as dealt with in Chapter x., is of a purely descriptive nature, and includes the usual types. The Morton gear might have been included as a curiosity, as a goods engine has been satisfactorily running for some years on the North British Railway fitted with it. Of

valves of different descriptions we find much valuable information, including the piston type of valve, largely used at sea, and now, under the name of Smith's Patent, being experimented with on the North-Eastern and Midland Railways, the Highland Railway having tried and discarded it some short time ago. Valve gear in detail comes next, and we cannot agree with the author when he says that in inside cylindered engines expansion links with one bracket only are used. This is the exception and not the rule—*vide* the practice of the Brighton, Caledonian, and North British Railways.

Taken as a whole, the descriptions of all detailed work represent modern practice, and the engineering student will find much to learn in these pages. Chapter xiii. deals with the all-important question of the general construction and design of the locomotive boiler; after discussing the questions which really concern its dimensions, the question of various types is described. The now fashionable Belpaire type is badly illustrated in Fig. 155, which must represent an American or continental type of boiler, although the author does not say so, and the arrangement of stays and plating is certainly not of British design. The Belpaire boilers designed by Messrs. Neilson, Reid, and Company for the Mexican railways some years ago might be taken as fair representatives of this type of British design, and should be illustrated in a future edition—they being the prototype of some running on more than one British railway.

In order to allow freedom for expansion of the tubeplates of Belpaire boilers of British design, it is usual to arrange the last transverse rows of vertical stays so that any vertical movement of the fire-box will not be transmitted to the wrapper-plate; moreover, a similar arrangement might be placed above the door-plate with advantage.

On the use of steel in boiler construction we find much valuable information, but we most distinctly disagree with the author when he states on p. 200 that steel of boilerplate quality contains a maximum of 15 per cent. and a minimum of 10 per cent. of carbon! What has happened to the decimal point? The author, like many others, has not yet got over the idea that steel-plates require very special treatment in the flanging-shed and boiler-shop. This is not the case; steel-plates, as manufactured to-day, are more uniform in quality, and are certainly as easily worked as Yorkshire iron. On p. 215 we read that on the Caledonian Railway the roof of the fire-box is supported by vertical stays fastened in series of threes in a longitudinal direction. These stays were on the scrapheap years ago.

On the question of machine riveting, our author maintains that subsequent caulking of rivet-heads is unnecessary. If this is the case, why do our best firms of locomotive builders invariably carefully caulk every rivet-head before the boiler is tested? They work for a profit, not for honour and glory.

Mr. Ravenshear gives a very full description of continental and American locomotive practice, with illustrations, which will be found towards the end of this volume, besides the usual descriptive accounts of the vacuum and Westinghouse railway brakes. Taken as a whole, this work is one of the best of its kind that has been published on the subject. The strains experienced by various parts of a locomotive during work are impossible to calculate, and, therefore, it must be every-day experience that can train the successful designer. For this reason a text-book on this subject can only be descriptive of work done which successfully withstands the usages of every-day work.

NORMAN J. LOCKYER.

## THE HEREFORD EARTHQUAKE OF 1896.

*The Hereford Earthquake of December* 17, 1896. By Charles Davison, Sc.D., F.G.S. Pp. xi + 303. (Birmingham: Cornish, 1899.)

AFTER an interval of more than two years Dr. Charles Davison has at last given us, in a volume of 303 pages, his long-promised account of the earthquake which, in the early morning of December 17, 1896, rudely awakened the inhabitants of the Severn Valley.

When we look at the 2902 epitomised accounts which Dr. Davison has brought together respecting an earthquake which in many countries would have been regarded with as much indifference as a sprinkling of rain, we are inclined to ask whether the examination of this long series of remembrances, obtained from a community more or less excited by phenomena with which they had but little experience, would be likely to lead to results of any value. Had this earthquake originated in a sparsely populated country where there were difficulties in obtaining accurate time, the analysis of observations taken under such conditions would, to a large extent, have been labour in vain.

Although no special provisions are taken in Britain for the observation of earth tremors, as the one now under consideration occurred at the waking hour of many millions of people who, lying on their beds, were in the best possible position for noticing slight vibrations, and for the most part had the means of obtaining fairly good time, and above all were intensely interested in the phenomenon they experienced, the conditions for obtaining a large series of valuable records were unusually favourable. Within the epifocal area where chimneys fell or were "hurled to some distance"—which we doubt—and buildings were unroofed, and within at least one hundred miles of the same, all the observers had but little doubts as to the nature of the movements they experienced. Beyond these limits in very many instances it is likely that many observers only realised and remembered that a something or other had rattled, perhaps the window or a lamp-shade, after they had read their morning papers, and with feelings of satisfaction as participants in an alarming disaster, they threw in their notes and helped to complete an important chapter in British seismology. If every time a window was slightly shaken, glasses rattled, or other unaccountable microphonic disturbances were perceptible could be recorded, and the collected results analysed, it is extremely probable that the seismic register for the British Islands would be considerably increased.

Before discussing the catalogue of observations, Dr. Davison sets out by showing that there is a reality of connection between the majority of earthquakes and the

slow but intermittent growth or extension of faults. This done, he draws on a map isoseismals or curves surrounding all places at which the intensity of the movement, as represented in certain cases by its destructivity, has been approximately equal. The most important of these is isoseismal number 8, which is the innermost and contains some seventy-three places at which there was structural damage. It is oval or elliptical in form, with its major axis forty-three miles in length running from N.W. to S.E., and encloses the towns of Hereford, Ross and Gloucester. Outside this are the isoseismals numbered 7, 6, 5 and 4, a series which become more and more circular in form, the latter extending beyond Wexford and Dublin in the west, and Norwich on the east.

From the form of these isoseismals, especially that of No. 8, which is the most important, by reasoning familiar to seismologists it is shown that the disturbance originated along a line of fault which dips to the north-east, and has a strike coinciding with the major axis of the innermost of these curves of equal intensity.

It appears that two series of vibrations were noted, which at different places were different in intensity and duration. An examination of the records relating to these leads to the conclusion that the principal shock originated from two foci along the line of fault, one near to Hereford, and the other near to Ross.

At this point Dr. Davison is hand in hand with the geologist who, having already mapped faults bounding the triangular area of May Hill, south-east of Hereford, now sees that there are good reasons for supposing that one of these is but the south-eastern extension of that revealed by the distribution of vibrational effects accompanying the Hereford earthquake. Davison's fault therefore throws new light upon the geotectonic relationships amongst the older rocks in Western Britain, and that there is such a rupture in the Old Red Sandstone to the east of Hereford may at any time be of importance not only to the geologist but to the engineer.

Another set of lines discussed are those passing through places at which the same phase of the earthquake was felt at the same instant. These are the well-known coseismal lines, which are less elongated than the isoseismals, but have their major axis in approximately the same direction. From the distances between them, velocities of transit varying between 2814 and 3095 feet per second are calculated, suggesting, but not on very certain grounds, an apparent increase in the velocity of earthquake transmission as it radiates. With a knowledge of the velocity between any two coseismals and the distance of one of them from the epicentre, the time of origin of the earthquake is determined as having been at 5h. 31m. 45s. a.m.

To the seismologist, the most striking feature in Dr. Davison's work is his treatment of the sound phenomena. Mr. Mallet in his classical work on the Neapolitan earthquake of 1857 gives us a chapter on the sounds that attend a shock, and which are produced by steam or by the rending of rocks. In a previous publication, Dr. Davison has given us his views as to the origin of earthquake sounds, which he attributes to the slipping or mechanical disturbance in the marginal region of the seismic focus.

In the present work, he gives us a map showing isacoustic lines or lines of equal sound intensity. Any one of these lines passes through districts in which the percentage of observers who noted a sound are equal, and they are therefore more strictly speaking, as the author states, lines of equal sound audibility.

The major axis of these closed curves is, roughly speaking, at right angles to that of the iso- and coseismal curves. More accurately it is a hyperbolic trace which follows the band, along which it is shown that the two series of vibrations from the two earthquake foci are superimposed.

The general result arrived at from the study of these isacoustic lines is that they confirm the conclusion that there were two distinct, or nearly distinct, regions along the fault line from which vibrations radiated, and that the slip at the northern end of this line occurred a few seconds earlier than at the southern end. In this discussion of sound phenomena we have something distinctly original.

The shock was felt less upon hard rocks and on high ground than on soft ground and in valleys. In the Bangor-Anglesey district the shock was felt most powerfully upon the carboniferous and ordovician rocks, and less upon the volcanic materials and schists. It was felt underground in several mines; at some places it produced feelings of nausea, and many instances are recorded of horses, cows, dogs, sheep, pheasants and other birds having exhibited symptoms of alarm.

Without going further into Dr. Davison's work, taking the same as a whole, he is to be congratulated on having extracted from materials which at first sight are of very little promise a quantity of valuable and novel information. The Hereford earthquake was a transient shivering of an exceedingly small portion of the earth's crust; and, considering that there may be 10,000 of these occurring every year, this one appears to have been more carefully studied than any of its predecessors of equal magnitude.

Had the author contented himself with analysing half the facts he has collected, although the same would have made a column of print 100 yards in length, the probability is that, beyond noting a number of incidents of local interest, our knowledge of seismic phenomena would have not been materially increased. As it is, especially perhaps with regard to isacoustics, a distinct advance has been made, and in the future we shall find others working on similar lines. J. MILNE.

## *A BIOLOGICAL RECORD.*

*L'Année Biologique.* Comptes rendus annuels des travaux de Biologie générale, publiés sous la direction de Yves Delage, professeur à la Sorbonne, avec la collaboration d'un Comité de Rédacteurs. Secrétaire de la rédaction, Georges Poirault, Docteur ès sciences. Première année (1895). Pp. xlv + 732. 1897. Deuxième année (1896). Pp. xxxv + 808. 1898 (Paris: Schleicher Frères.)

IN one of the Woods Holl Biological Lectures, entitled "Bibliography: a Study of Resources," Dr. Charles Sedgwick Minot, himself the author of one of the standard zoological bibliographies, compares the biological biblio-

grapher to an explorer in a forest "who finds no open way to travel, but must laboriously hunt for his specimens . . . as they lie scattered, unclassified, and, all too often, concealed." These words were spoken in 1895, but now the two bulky volumes before us show that the biologist need not lose hope in the ever thickening jungle of literature. They form a thoroughly competent biological record for two years, and, whatever may be their defects in detail, they deserve a hearty welcome. If Prof. Delage's undertaking is supported as it should be, not only by subscribers, but by co-operators, it should do much in the future to widen the interest of naturalists in the great problems of biology, to raise the standard of biological scholarship, and to curb the impatience of those who hasten to ill-advised reiteration of tales many times told.

This "biological record" does not compete with its seniors—the *Zoological Record*, the Naples *Jahresbericht*, and others akin, nor with the Zürich Concilium over which Dr. Field presides, nor with the *Journal of the Royal Microscopical Society*, the *Zoologisches Centralblatt*, and their like, for, as the title indicates, it aims at recording and summarising and appreciating those papers which deal with or have a bearing on *general biological problems.* It is a record for biologists, not for systematists, anatomists, physiologists, embryologists, and palæontologists, who have their own "resources"—though none would be the worse of availing himself of this also.

The task is somewhat similar to that which has been attempted for many years in the first part (General Subjects) of the *Zoological Record*, and in the corresponding portion of the Naples *Jahresbericht;* but there are several notable differences. The meshes of the net used by *L'Année Biologique* are finer than in the others ; it is botanical and anthropological as well as zoological ; and there are more or less adequate signed summaries of all the important papers recorded. On the other hand, it is only fair to notice that the Records which are issued from the Zoological Society of London, by the Naples station, and by the botanists, come much more nearly up to time. Thus, we must be ungrateful enough to observe that the third volume of *L'Année Biologique* dealing with 1897 is not yet to hand ; and it is of course obvious that the editors of the later records have the advantage, which no one grudges, of being able to utilise the labours of their more up-to-date predecessors.

What the editors understand by the term "biological" is at once seen from the table of contents, which includes about a score of subjects : the cell ; the sex-cells and fertilisation ; parthenogenesis ; asexual reproduction ; ontogeny ; teratogeny ; regeneration ; grafting ; sex ; polymorphism, metamorphosis, and alternation of generations ; latent characters ; correlation ; death, immortality, and the germ-plasm ; general morphology and physiology ; heredity ; variation ; origin of species ; geographical distribution ; nervous system and mental functions ; and general theories. It is easy to criticise, but it seems to us that this classification is unwieldy, and it has certainly led to an unnecessary amount of repetition. We notice, for instance, at least one case where the same paper has been summarised twice at considerable length by different recorders, which, however interesting, is luxurious.

Prof. Yves Delage and Dr. Georges Poirault deserve the gratitude of all biologists for their monumental record, though perhaps only bibliographers will adequately appreciate the magnitude of the labour involved. It is of course a co-operative work, organised from the contributions of a large body of workers in Europe and America, and, as our own share has been a minimal one, we are bold to say that the co-operators also deserve some gratitude for their labour of love. An interesting and valuable feature is the general discourse which precedes most of the sections, sometimes rising to the dimensions of a comprehensive essay, as in the case of correlation, phagocytosis, and geographical distribution. There seems, indeed, just a hint of overdoing this part of the record.

Every one will agree that the prime and indispensable virtue of any bibliography is accuracy, and in this respect we must in honesty say that there is still room for improvement in *L'Année Biologique.* We took the trouble to correct three pages in the first volume, and the result is certainly not beautiful to look upon. We hasten, however, to add that the inaccuracies affect the letter rather than the spirit of the bibliographer's laws, and that the second volume has attained to a high standard. We ourselves well know how insidiously mistakes creep in, and we are in no mood for fault-finding, yet it must be remembered that accuracy comes first in the criteria of bibliographic work. With a task so huge, the only hope is that there may be more generous co-operation. Surely some of those who make game of a busy recorder's mistakes might sometimes remember that amelioration for the future will be furthered by the simple device of sending in copies of their works to be at hand both in the compilation and in the proof-reading of the record.

Since the volumes before us were published, we have thoroughly tested their usefulness, and, frankly, we cannot but be surprised if every serious biologist does not agree with us in calling them indispensable. As for those gay knights-errant who care not for any of these bibliographies, we can only regret that they thereby do injustice to their genius.

And, finally, we should say in welcoming this biological record, that as there is a social as well as a scientific aspect of bibliography, it seems to us a matter for genuine congratulation that the editors have endeavoured to place their record upon an international basis—an endeavour which will, we hope, eventually have further development in an increasing recognition of the cosmopolitanism of science.

J. A. T.

## OUR BOOK SHELF.

*A Short History of Astronomy.* By Arthur Berry, M.A. Pp. xxxi + 440. (London : John Murray, 1899.)

READERS of this volume will probably be divided into two classes, those who are pleased with any description of a subject, however disconnected, and those who wish the whole of the ground to be covered, even though many details may only be slightly touched upon. To the former the book will offer much pleasant reading, but it is likely that the latter will be disappointed with the treatment of the matter as it is here presented.

Chapter i. is entitled "Primitive Astronomy," much of the space, however, being taken up by explanations of the various definitions of the celestial sphere. Considering the amount of painstaking labour which has been devoted by many modern inquirers to proving the extent of the astronomical knowledge of the Egyptians and other ancient nations, as evidenced by their temples and monuments, it is rather hard to be told that this is but "a plausible interpretation of these peculiarities."

Chapter ii., dealing with "Greek Astronomy" from 600 B.C. to 400 A.D., is much more readable. Commencing with the introduction of the calendar and its various alterations, the successive celestial systems figured out by Plato, Aristotle, Aristarchus, Hipparchus, Ptolemy, &c., are very lucidly explained. The comparatively slow development of astronomy during the Middle Ages, from 600 A.D. to 1500 A.D., forms the subject of Chapter iii. Towards the end of this period, the first authentic conceptions of the celestial bodies being situated on concentric crystal spheres were enunciated.

The fourth chapter is entirely devoted to the enormous impetus given to astronomical knowledge by the teachings and work of the great Copernicus, extending over the period 1473 A.D. to 1543 A.D. The succeeding five chapters deal with the life-works of Tycho Brahe (1543-1601), Galilei (1564-1642), Kepler (1571-1630), and Newton (1643-1727).

Chapter x. deals with the progress of observational astronomy during the eighteenth century, the chief workers during this period being Flamsteed, Halley, Bradley, Maskelyne and Lacaille; while the following chapter reviews the mathematical aspect of the science for the same epoch, Euler, D'Alembert, Lagrange and Laplace occupying the places of honour.

Chapter xii. is devoted to the work of Herschel from 1738 to 1822. These few chapters are extremely interesting, but it is very disappointing to find that the astronomical progress of the nineteenth century is crowded into the remaining fifty pages. Considering the enormous advances made during this period, this is wholly out of proportion, and in consequence many important matters have either been merely mentioned or omitted altogether. For example, although the book is sufficiently up to date to mention the discovery by Prof. Nasini of a terrestrial gas whose spectrum contained a line probably coincident with the chief coronal line, it is distressing to find no mention whatever made of the gigantic Draper Catalogue of Prof. Pickering dealing with the classification of stars according to their spectra; indeed, the only reference to photographic work on stellar spectra is in connection with motion in the line of sight. Again, the whole matter of the organisation, &c., of the great photographic survey is contained in twelve lines. The mathematical portions of the science are, however, treated much more generously.

The author has attempted a very difficult task in condensing the whole history of astronomy into so small a volume, and it is from this standpoint that the book must be judged. Although to the individual there is much that is unsatisfactory, the work contains a great amount of useful information, which will no doubt cause it to find favour.

*Outlines of Physical Chemistry.* By A. Reychler. Translated by John McCrae, Ph.D. Pp. xvi + 276. (London and New York: Whittaker and Co., 1899.)

THE choice and arrangement of the subject-matter of this book is fairly satisfactory. It includes the laws of chemical combination, the atomic hypothesis, the gas laws, vapour density, the specific heat of solids and the periodic system. The second part contains a fuller discussion of the properties of gases and the critical phenomena, the connection between chemical constitution and the boiling point, volume, refraction and rotation of liquids, and the properties of solutions. The third part deals with thermo- and electro-chemistry and the nature of solutions of salts. The fourth part treats of chemical equilibrium and the velocity of reactions. The treatment of this subject-matter does not, however, appear to be distinguished by any striking originality or other special merit which would warrant the translation of the book. On p. 2, the law of constant proportions is stated thus: "In order to form a substance, it is always necessary to have the same elements united in the same proportions." This is much the same as saying that any two samples of the same kind of matter have the same composition. As Mr. Hartog pointed out in these columns, a correct statement of the law of constant proportions should emphasise the view, upheld by Proust, that the proportions in which two substances combine alter *per saltum*, and that there is not (as Berthollet believed) a series of compounds of all intermediate compositions bridging over the gaps.

It might have been mentioned that the conclusions drawn by Traube from his work on the volumes of liquids (pp. 66-70) are not universally accepted.

The account given of the reasons for assuming the existence of free ions in electrolytes is so incomplete as to be misleading. The work of Clausius is not mentioned, and the considerations which led Arrhenius to his extension of the hypothesis of Clausius do not receive much better treatment.

The evolution of heat accompanying the solution of substances like hydrochloric acid or caustic soda in water is regarded by the author as an insuperable objection to the ionic hypothesis in its usual form. To overcome this objection he proposes a modified hypothesis in which the sodium ion in solutions of sodium salts, for example, is supposed to be combined with an hydroxyl group. In order to explain the phenomena of electrolysis, the charged sodium ion is supposed to be continually passing from one hydroxyl group to another; an exactly similar supposition, however, led Clausius to assume that the ions spend at least some portion of their existence in the free state, so that the author's modification appears to consist in the addition of a new (and unnecessary) hypothesis to the old one. A discussion of this kind is, in any case, somewhat out of place in a book intended for beginners.

The translation might have been better; we do not like "luminary vibration" (p. 81); "the ascension of the mercury" in a thermometer (p. 137); "measurement instruments" (p. 189); "the comparativeness of our results" (p. 197); "electrolysable compounds" instead of electrolytes; "this scientist" (presumably *ce savant* in the original); "the momentary course of the reaction" (p. 249) instead of the velocity of the reaction at a given instant.

*Views on Some of the Phenomena of Nature.* By James Walker. Part II. Pp. vi + 187. (London: Swan Sonnenschein and Co., Ltd.)

AMONG the views expressed are that "Light is the sensation produced through the medium of the organ of vision by the action of multitudinous effluvia, exhaled by the sublimation of the incandescent substances which exist in the sun's photosphere, and which are borne into space by an eruptive force, emanating from the contracting body of the sun." After a review of a number of scientific and unscientific statements, the book concludes with the question "As to the 'mode of motion' theory of heat, or the 'wave' theory of both light and heat, of electricity and ether, is it any more than a fiction of the imagination?" Persons who would reply in the negative will be impressed by the arguments of Mr. James Walker.

## LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### Physical Measurement of Public Schoolboys.

I ENCLOSE photographs of two lecture diagrams which were used for a paper on the physical development of public schoolboys read to the Medical Officers of Schools Association last Easter. The curves represent the various different schemes of growth followed by schoolboys from the age of $10\frac{1}{2}$ to $18\frac{1}{2}$, according as they are developing into large, small, or medium sized men. They are constructed from corresponding series of curves of distribution, which curves are constructed from a large number of observations recorded at various public schools. From 14,000 to 15,000 observations have been collated for the construction of each series, and I regard them as being fairly trustworthy in form between the ages of 12 and 18. Beyond these limits the form of the curves may be slightly at fault, owing both to insufficient number of observations and to the process of natural selection which influences the physical status of the majority of boys who come early and stay late at a public school. The curves in Fig. 1 are constructed by marking off on the vertical line through each age the various heights at which the curve of distribution for that age crosses the 5 per cent., 10 per cent., 15 per cent., . . . 95 per cent. lines. Each series of corresponding points is then joined up by a flowing curve, with the result shown. The central line, between the numbers 10 and 11, shows where the various curves of distribution cross the 50 per cent. line, and consequently indicates the scheme of growth of the mean boy.

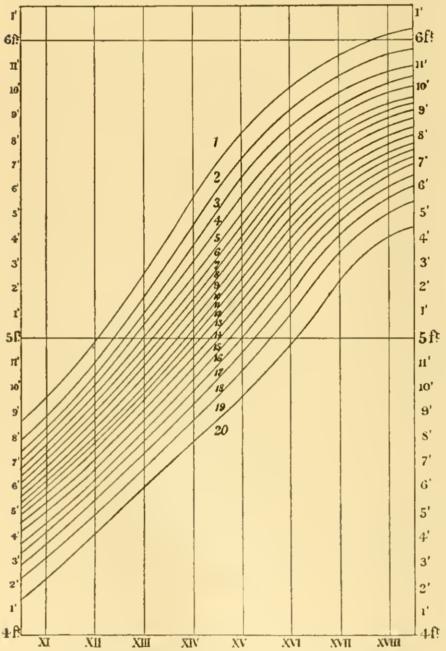



FIG. 1.—Grade curves for height of public schoolboys from $10\frac{1}{2}$ to $18\frac{1}{2}$ years of age. The figures on the base line refer to age. The figures down the centre of the diagram are the numbers of the grades, which are bounded by the two curves between which the several numbers are placed. There is no lower limit to grade 20, nor upper limit to grade 1.

It was contended in the paper that since each of these curves represents the growth of a boy, who develops in such a manner as to preserve always the same relative position amongst his fellows, they give an accurate idea of the growth which may be reasonably expected from a boy at any stage of his development, whatever his physical status may be. A glance at the diagram will show that the rate of growth, which is measured by the pitch of the curves, varies considerably for boys of the same age but of different physique. The period of maximum growth is reached much sooner by a boy of a high grade than by one of a low grade, and lasts much longer. Thus the steepest pitch of the topmost curve occurs between the ages of $13\frac{1}{2}$ and $14\frac{1}{2}$, and is sensibly uniform during that period, the corresponding steepest pitch in the mean line lies between the ages of 15 and $15\frac{1}{2}$, in the lowest line it lies between $16\frac{1}{2}$ and 17. Consequently, during the period of fastest growth, all boys may be expected to grow at nearly the same rate; but this rate of growth is reached by some boys three or four years later than by others.

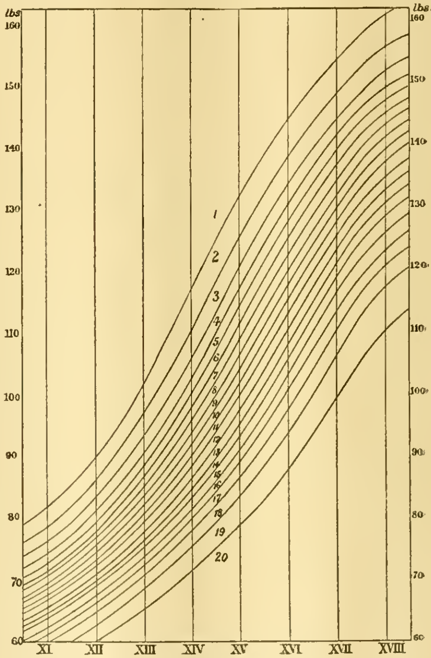



FIG. 2.—Similar grade curves for weight.

Fig. 2 represents the corresponding series of curves for weight, and teaches much the same lessons; it is evident, however, that the rate of growth in height declines much more rapidly after the period of maximum growth is passed than the rate of growth in weight, consequently boys of the same height but of different ages may be expected to differ considerably in weight. That this is generally the case was clearly shown by another set of curves exhibited at the lecture.

The curves shown have been used for constructing tables of grades, by means of which the limits of twenty grades are fixed, in some one of which a boy can be immediately placed if his measurements are known. From the mode of construction it is evident that, *à priori*, each of these grades is equally probable. The tables have in actual practice been found to be of great use in estimating the progress of individuals, and of gymnastic

classes, &c. Thus an analysis of the grades o. chest-girth of 255 boys before and after a three terms' course of compulsory gymnastics showed that the following improvement had been made. The numbers in the lower line give the percentage of the boys examined, who made the number of grades improvement indicated in the line above.

| Improvement :— | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 gr. | 2 gr. | 3 gr. | 4 gr. | 5 gr. | 6 gr. | 7 gr. | 8 gr. | 9 gr. | 10 gr. | 11 gr. |
| Per cent. :— | | | | | | | | | | |
| 11 | 11 | 12 | 10 | 7 | 6 | 4 | 4 | 1 | 4 | 1 |

This with the omitted fractions gave 73 per cent. of the boys who had made more or less marked improvement relative to the general mass of boys of their age, the improvement in some cases being very marked indeed.

An analysis of the growth of 161 boys by means of their grades showed that the scheme of growth corresponded to the scheme indicated by the curves in the diagram in 31 per cent. of the cases examined. There was a steady rise relative to this standard in 17 per cent.; a steady fall in 10 per cent.; a period of rise followed by one of fall, or *vice versâ*, in 18 per cent. In 9 per cent. the variation was erratic, and the remaining 15 per cent. probably belonged to the first group; but not within the limits of variation allowed.

In 68 per cent. the type of structure, as indicated by the relation of height to weight, was stable throughout the period examined; but in about one-fourth of these cases there was a considerable constant difference between the grades of height and weight, amounting in the most extreme cases to as much as eight grades.

The lesson drawn from these observations was that, in order to form a correct opinion relative to a boy's physical progress by means of his measurements, it is very desirable to keep a regular record of his growth, in order that the general scheme of his growth may be determined, and that any irregular fluctuations due to external and removable causes may be noted and properly dealt with. C. H.

### The Giant Tortoises of the Galapagos.

I NOTICED in your issue of June 15 a paragraph about the Galapagos tortoises. I do not know if this information is of any interest, but during my residence in Hawaii I knew of two living there. One of them lived in a garden near Hilo, and belonged to the late Captain Thomas Spencer; I last saw it about 1880. The other one lived on the Waimea plains in a perfectly wild state, and I used frequently to come across it when out shooting. It used to wander about within a radius of three or four miles.

It was blind of one eye, and its shell had lichen growing on it, and it could move about with a man sitting on its back.

I last saw it in 1890, but it may possibly be still living; this, however, could easily be ascertained.

They were, I believe, brought to Hawaii from the Galapagos in whalers, and were of great age. If desired, I shall endeavour to find out if they are still alive. W. HERBERT PURVIS.

10 Alexandra Place, St. Andrews, Fife.

### School Laboratory Plans.

COLLEGE plans are not always safe precedents. Boys need more supervision. Can any of your readers advise as to the best arrangement of benches for a class of twenty-four to thirty boys, aged fourteen to seventeen, doing chemistry and physics with elementary quantitative experiments?

(1) Is the double back-to-back bench the best form? It may economise woodwork, but it makes the class face both ways, and attention to verbal instruction is less easy.

(2) Is the superstructure of shelving necessary? If qualitative analysis is not done, fewer bottles are needed. The superstructure hinders conversation across double benches, but it stops supervision also.

(3) What is the best way of arranging the benches so as to allow of supervision and keep wall spaces free for shelving? They may be (*a*) all round the wall, leaving no space for shelves and cupboards; or (*b*) single bench along two walls and double bench down the middle; or (*c*) across the room, double benches alternating with windows, well lighted but difficult to supervise; (*d*) central aisle with double bench extending to walls right and left; (*e*) double benches, lengthways, free from walls; (*f*) single benches, cross-ways, like the desks of an ordinary class-room.

I shall be grateful for any help or advice.

Bootham School, York, June 23. HUGH RICHARDSON.

### Pair of Brazilian Marmosets Breeding in England.

A PAIR of marmosets, which for the two past winters have had a free run of our greenhouse and garden (in Buckinghamshire), produced two young ones on May 24. They seem to thrive on freedom and exercise, and the young ones are now beginning to feed themselves. In hot weather they like to remain out all night, but at first they came in to their box in the greenhouse every evening, the male parent always carrying the twins on his back, their little round furry heads merely looking like small excrescences each side of his neck; and only handing them to the mother at feeding-times, and then carefully lifting them back with both hands and settling them into position, where they seem to cling on without being held.

Their favourite garden house appears to be an old bird's nest, rather high up in a pink thorn-tree, some distance from the greenhouse. They very rarely come down to the ground, but the female will answer a call and come to feed from the hand. Bananas, milk and water, insects and young birds are the foods they like best. DORA WHITMORE.

## *THE DIFFRACTION PROCESS OF COLOUR-PHOTOGRAPHY.*

THE production of colour by photography has been accomplished in two radically different ways up to the present time. In one, the so-called Lippmann process, the waves of light form directly in the photographic film laminæ of varying thickness, depending on the wavelength or colour of the light. These thin laminæ show interference colours in reflected light in the same way that the soap-bubble does, and these colours approximate closely to the tints of the original.

The technical difficulties involved in this process are so great that really very few satisfactory pictures have ever been made by it. The other, or three-colour process, has been developed along several distinct lines, the most satisfactory results having been produced by Ives with his stereoscopic "Krōmskōp," in which the reproduction is so perfect that, in the case of still-life subjects, it would be almost impossible to distinguish between the picture and the original seen through a slightly concave lens. The theory of the three-colour method is so well known that it will be unnecessary to devote any space to it, except to remind the reader of the two chief ways in which the synthesis of the finished picture is effected from the three negatives. We have first the triple lantern and the Kromscope in which the synthesis is optical, there being a direct addition of light to light in the compound colours, yellow being produced, for example, by the addition of red and green. The second method is illustrated by the modern trichromic printing in pigments. Here we do not have an addition of light to light, and consequently cannot produce yellow from red and green, having to produce the green by a mixture of yellow and blue. Still a third method, that of Joly, accomplishes an optical synthesis on the retina of the eye, the picture being a linear mosaic in red, green and blue, the individual lines being too fine to be distinguished as such.

The diffraction process, which I have briefly described in the April number of the *Philosophical Magazine*, is really a variation of the three-colour process, though it possesses some advantages which the other methods do not have, such as the complete elimination of coloured screens and pigments from the finished picture, and the possibility of printing one picture from another. The idea of using a diffraction grating occurred to me while endeavouring to think of some way of impressing a surface with a structure capable of sending light of a certain colour to the eye, and then superposing on this a second structure capable of sending light of another colour, without in any way interfering with the light furnished by the first structure. This cannot, of course, be done with inks, since if we print green ink over red, the result will not be a mixture of red light and green

light, but almost perfect absence of any light whatever; in other words, instead of getting yellow we get black. Let us consider first how a picture in colour might be produced by diffraction. Place a diffraction grating (which is merely a glass plate with fine lines ruled on its surface) before a lens, and allow the light of a lamp to fall upon it. There will be formed on a sheet of paper placed in the focal plane of the lens, an image of the lamp flame, and spectra, or rainbow-coloured bands on each side of it. Now make a small hole in the sheet of

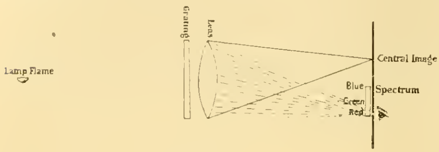



FIG. 1.

paper in the red part of one of these spectra. This hole is receiving red light from the whole surface of the grating, consequently if we get behind the paper and look through the hole we shall see the grating illuminated in pure red light over its whole extent. This is indicated in Fig. 1, where we have the red end of the spectrum falling on the hole, the paths of the red rays from the grating to the eye being indicated by dotted lines. Now the position of the spectra with reference to the central image of the flame depends on the number of lines to the inch with which the grating is ruled. The finer the ruling the further removed from the central image are the coloured bands. Suppose now we remove the grating in Fig. 1, and substitute for it one with closer ruling. The spectrum will be a little lower down in the diagram, and instead of the red falling on the hole, there will be green; consequently, if we now look through the hole, we shall see this grating illuminated in green light. A still finer ruling will give us a grating which will appear blue. Now suppose that the two first gratings be put in front of the lens together, overlapping as shown in Fig. 2. This combination will form two overlapping spectra, the red of the one falling in the same place as the green of the other, namely on the eye-hole. The upper strip, where we have the close ruling, sends

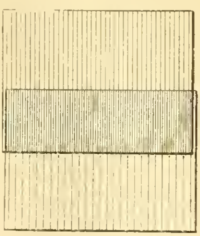


FIG. 2.

green light to the eye and appears green; the under strip, with the coarser ruling, sends red light to the eye and appears red, while the middle portion, where we have both rulings, sends both red and green light to the eye, and in consequence appears yellow, since the simultaneous action of red and green light on any portion of the retina causes the sensation of yellow. In other words, we have in superposed diffraction gratings a structure capable of sending several colours at once to the eye.

If we add the third grating, we shall see the portion where all three overlap illuminated in white, produced by the mixture of red, green and blue light.

Three gratings with 2000 lines, 2400 lines, and 2750 lines to the inch, will send red, green and blue light in the same direction, or, in other words, to the same spot on the screen behind the lens.

Suppose, now, we have a glass plate with a design of a tulip, with its blossom ruled with 2000 lines to the inch, its leaves ruled with 2400, and the pot in which it is growing ruled with 2750 lines, and place this plate before the lens. On looking through the hole we shall see a red tulip with green leaves growing in a blue pot. Thus we see how it is possible to produce a coloured picture by means of diffraction lines, which are in themselves colourless. Those portions of the plate where there are no lines send no light to the eye, and appear black.

We have now to consider how this principle can be applied to photography. That photographs which show colour on this principle can be made, depends on the fact that a diffraction grating can be copied by contact printing in sun-light, on glass coated with a thin film of bichromated

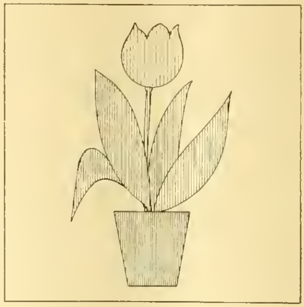


FIG. 3.

gelatine. The general method which I have found best is as follows. Three gratings ruled on glass with the requisite spacing were first prepared.[1]

To produce a picture in colour three negatives were taken through red, green, and blue colour filters in the usual manner. From these three ordinary lantern-slide positives were made. A sheet of thin plate-glass was coated with chrom gelatine, dried, and cut up into pieces of suitable size; one of these was placed with the sensitive film in contact with the ruled surface of the 2000-line grating, and the whole covered with the positive representing the action of the red light in the picture. An exposure of thirty seconds to sunlight impressed the lines of the grating on the film in those places which lay under the transparent parts of the positive. The second grating and the positive representing the green were now substituted for the others, and a second exposure was made. The yellows in the picture being transparent in both positives, both sets of lines were printed superposed in these parts of the picture, while the green parts received the impression of 2400 lines to the inch only.

The same was done for the blue, and the plate then washed for a few seconds in warm water. On drying it appeared as a coloured photograph when placed in front of the lens and viewed through the hole in the screen.

[1] These gratings were ruled for us on the dividing engine at Cornell University, through the courtesy of Prof. E. L. Nichols.

Proper registration during the triple printing is secured by making reference marks on the plates. A picture of this sort once produced can be reproduced indefinitely by making contact prints, since the arrangement of the lines will be the same in all of the copies as in the original. The finished picture is perfectly transparent, and is merely a diffraction grating on gelatine with variable spacing. In some parts of the picture there will be a double grating, and in other parts (the whites) there will be a triple set of lines. Having had some difficulty in getting three sets of lines on a single film in such a way as to produce a good white, I have adopted the method of making the red and green gratings on one plate, and the blue on another, and then mounting the two with the films in contact. It is very little trouble to multiply the pictures once the original red-green grating picture is made.

The pictures are viewed with a very simple piece of apparatus, shown in Fig. 4, consisting of a lens cut square like a reading glass, mounted on a light frame provided with a black screen perforated with an eye-hole through which the pictures are viewed. The colours are extremely brilliant, and there is a peculiar fascination in the pictures, since if the viewing apparatus be slowly turned so that its direction with reference to the light varies, the colours change in a most delightful manner, giving us, for example, green roses with red leaves, or blue roses with purple leaves, a feature which should appeal to the impressionists. The reason of this kaleidoscopic effect is evident, for by turning the viewing apparatus we bring the eye into different parts of the overlapping spectra.

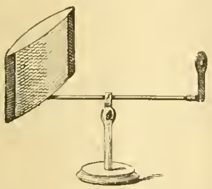


FIG. 4.

It is possible to project the pictures by employing a very intense light, and placing a projecting lens in place of the eye behind the perforation in the screen. Of course a very large percentage of the light is lost, consequently great amplification cannot well be obtained. I have found that sun-light gives the best results, and have thrown up a three-inch picture on a four-foot sheet so that it could be seen by a fair-sized audience.

By employing a lens of suitable focus it is possible to make the viewing apparatus binocular, for similar sets of superposed spectra are formed on each side of the central image by the gratings, so that we may have two eye-holes if the distance between the spectra corresponds to the interocular distance.

It is interesting to consider that it is theoretically possible to produce one of these diffraction pictures directly in the camera on a single plate. If a photographic plate of fine grain were to be exposed in succession in the camera under red, green, and blue screens, on the surfaces of which diffraction gratings had been ruled or photographed, the plate on development should appear as a coloured positive when seen in the viewing apparatus. I have done this for a single colour, but the commercial plates are too coarse-grained to take the impression of more than a single set of lines. With specially made plates I hope to obtain better results.

R. W. WOOD.

## *LOCAL UNIVERSITY COLLEGES FOR LONDON.*

THE adequate provision of university education for London is by no means the simple and straightforward task which some people seem to imagine. From whichever of the many possible points of view the question of the education of London is considered, the anomalous position which has to be assigned to the greatest city in the world is the most noteworthy result of the investigation. If, for instance, an endeavour is made to estimate the comparative facilities offered for higher instruction in the metropolis with those to hand in other countries and in our own large provincial towns—judged on a basis of population—the results arrived at are as remarkable as they are interesting and instructive. The population of Scotland in 1896 was 4,186,849; yet located at Edinburgh, Glasgow, Aberdeen and St. Andrews are four well-equipped and largely endowed universities; while, in addition to these, is to be found at Dundee a college providing university education, and, though working with St. Andrews, in receipt of an annual grant of 1000*l.* from the Treasury. The population of the county of London was last year 4,504,766. If, as is done in the University of London Act, 1898, the towns within thirty miles of the university buildings are included, the population must be placed at a very much higher figure, viz. about six millions and three-quarters.

So that, keeping well within limits, and running no risk of any charge of exaggeration, the inhabitants of this metropolitan area may be said to considerably outnumber those of Scotland. When the universities and university colleges provided for this immense population are enumerated the total is ludicrously small. There is no teaching university, and but three university colleges—University College, King's College, and Bedford College. Of course, there are other colleges in London; but, in defining university colleges reference is made to the Treasury Minute of June 2, 1897, dealing with the grant in aid of the university colleges of Great Britain.

At University College there were in the faculties of Arts, Laws, and Science, in the session of 1895-6, 747 students, including engineering students. At King's College, during the same session, there were in Arts and Science 284 day students, 305 evening students, and 315 lady students. At Bedford College, the number of students throughout the same period numbered 176. The total number of persons receiving instruction of university standing in officially recognised institutions was consequently not much over 1500 during the year 1895-6.

If the populations up to date of the eight large towns in England provided with university colleges be added together, the total obtained is about 3,233,765. Similarly, Wales, with a population in 1891 of 1,501,163, has three university colleges, now together constituting the University of Wales. Not only in comparison with Scotland, therefore, but also by the side of Wales and the English provinces, London is seen to be extraordinarily deficient in properly authorised establishments the prime duty of which is to provide university instruction.

It may be urged at this stage that the work of the University of London Commission now being performed will, as it is intended it shall, completely alter the present unsatisfactory aspect of things, and that ere long provisions which will satisfy the most earnest advocate of higher education will be provided. But valuable as the coordination of effort which is likely to result from the inauguration of the new University of London will be, it can hardly be contended that to confer new powers upon certain existing colleges, and to rearrange the work of the staffs of institutions which have previously proved inadequate, will be a complete solution of the proper provision of university instruction for nearly seven millions of people.

It may be said at once that London should have a university college in each one of the various parts of the enormous district it covers. If one of the most important phases of the education imparted by the university is the intimate association of the undergraduate with his professors, the free exchange of views between the students themselves, and that mellowing effect which results from the feeling of a close connection with the corporate life of an important institution —then surely many small universities are incomparably better than one many-sided and multi-tentacled body with which the individual student can have no personal connection.

Nor is this conception of local universities in the different districts which build up the straggling wilderness we call London a dream of Utopia. As has been before pointed out in these columns, there already exist in London eleven polytechnic institutions, and the foundation stone of a twelfth has been laid. These, with four branches which have been established, provide sixteen separate centres scattered throughout an area which extends from Woolwich to Wandsworth in one direction, and from New Cross to Holloway in another. Why cannot some of these extensive buildings and lavishly furnished lecture-rooms and laboratories, representing half a million sterling in capital outlay, be utilised for the purpose of university work?

A reference to previous issues of NATURE will abundantly prove that there is nothing incongruous in undertaking university education in the lecture theatres, class-rooms and laboratories of these polytechnics. Comparatively few additions to the apparatus and fittings already provided would be necessary. Indeed, the work which has already been accomplished, valuable though it is, is scarcely return enough for the munificence of the City companies, the City parochial charities, the London County Council, private donors and others, which has placed the London polytechnics in their present condition of complete equipment.

A common retort to any such suggestion as has now been briefly stated—that the work of a university college is of a much more advanced nature than anything accomplished in a polytechnic—will not bear close examination. Several tests can easily be applied. An inspection of the lists of graduates of the London University, for instance, shows that a comparison of the numbers of successful candidates is all in favour of the polytechnics as compared with the university colleges. As it happens, it is possible to obtain the verdict of former professors of university colleges who are now engaged in the work of the polytechnics, and their assurance is that a greater quantity of advanced work, at all events in science, is done in the polytechnic. Moreover, the amount of work of an advanced type accomplished in English university colleges is usually somewhat exaggerated. A few quotations from a report presented in 1897 by Mr. P. H. Warren, President of Magdalen College, Oxford, and Prof. Liveing, Fellow of St. John's College, Cambridge, to the Lords Commissioners of her Majesty's Treasury, will justify this statement. Of one university college it is stated, "On the Arts side it cannot be said that at present any amount of work of a high standard is being done in the college," or later, "most of the work, both in arts and science, is of an elementary kind." Of another similar place of instruction, "With regard to the work now being done there, judged by University standards, a good deal of it is of an educational and preparatory rather than of an advanced and learned character." In the case of another college, "It is, therefore, not to be wondered at that the work on the Arts side should be still in a somewhat incipient stage, and mainly educational rather than learned." Of a fourth college it is reported, "A great deal of this work is in the nature of things of a somewhat preparatory kind, and there is throughout the college a great deal of work of not a very advanced character." Similar remarks concerning other university colleges might be multiplied, but quotations enough have been made to show that in apportioning the Treasury grant to university colleges the mere fact that elementary instruction is a part of the work carried on in the buildings is not considered a disqualification for also undertaking university instruction.

It is true that a very large part of the instruction of the 50,000 members and students enrolled by the London polytechnics takes place in the evening. This has been urged as evidence of the wide disparity between the methods of polytechnics and those of university colleges, but such an allegation reveals a want of knowledge of the prevalent conditions of instruction in university colleges. The evening classes of King's College, London, form an important part of the whole work of the institution. At Owens College, Manchester, a very complete system of evening lectures has been arranged for schoolmasters and others engaged during the day. The evening classes at University College, Liverpool, are strong and well attended, and are encouraged by the College authorities. The number of evening class students at Mason College, Birmingham, steadily increases. Besides the regular day work of the Bristol University College, there is an extensive system of evening classes, covering almost all the subjects taught in the college. At the Durham College of Science, Newcastle-upon-Tyne, there were in 1895-6, 1092 evening students compared with 499 day students. At Nottingham, in 1894-5, there were more than three evening students to one attending during the day.

Attention has already been called (No. 1523, p. 236) to the very complete arrangements in some of the polytechnics for instruction in the methods of scientific research, and to the excellent results, as evidenced by papers read to the learned societies, which have followed the lectures and demonstrations.

It would consequently appear that a judicious system of coordination and a little levelling-up would convert some of these sixteen institutions, which in the past ten years have had a phenomenal growth, and are steadily improving in status and influence, into satisfactory university colleges, bringing the highest order of culture to the very doors of the so-called metropolitan Philistines.

## *THE PLANS FOR ANTARCTIC EXPLORATION.*

IT is understood that the German Antarctic expedition for the year 1901 has now been fully organised. A grant of 60,000*l.* towards the expenses has been made by the Reichstag. Dr. Erich von Drygalski, one of the professors of geography in the University of Berlin, has been appointed the scientific leader, and an influential Committee is charged with perfecting the arrangements. This Committee is anxious that all the plans should be arranged for joint action, so that the German and British expeditions should supplement and reinforce one another at every point, thus ensuring the maximum return of scientific knowledge for the money expended. The expedition of the *Valdivia*, under the scientific leadership of Prof. Chun, is a proof of the splendid results which attend deep-sea expeditions under a scientific chief, if indeed the *Challenger* expedition did not supply proof enough. It is, however, still the opinion of some authorities in this country that an expedition which has to be carried in a ship must be under the sole and exclusive charge of a naval officer. The subject is one which

lends itself to discussion, and many illustrations may be adduced in favour of the arguments on either side.

It is gratifying to record that a national British expedition, well organised and excellently equipped, will be sent out to co-operate with the German expedition of 1901. That this expedition will be a purely scientific one is guaranteed by the fact that the organising body is a Joint-Committee of the Royal Society and the Royal Geographical Society, on which practical oceanographers and representatives of natural science are associated with the older generation of Arctic and Antarctic explorers. A responsible and representative directing body to which the choice of the leaders of the expedition can confidently be left is the first consideration, and this has been secured in the Joint-Committee. The first task of this Committee was to ascertain what resources would be available for carrying out the objects of the expedition. Three handsome contributions had been received—two of them from private individuals may indeed be termed magnificent—viz. 25,000*l*. from Mr. L. W. Longstaff, 5000*l*. from Mr. A. C. Harmsworth, and 5000*l*. from the Royal Geographical Society, while other subscriptions raised the total to 40,000*l*. Representations to the Government had produced no effect when the expedition was merely a project, but when Mr. Longstaff's donation made it certain that a British expedition would be equipped, Mr. Balfour, the First Lord of the Treasury, agreed to receive a deputation on the subject.

Accordingly, on June 22, a deputation waited upon Mr. Balfour at the Foreign Office, introduced by Sir Clements Markham, President of the Royal Geographical Society, and including Lord Kelvin, Sir Joseph Hooker, Sir Leopold McClintock, Sir Erasmus Ommanney, Dr. A. Buchan, Dr. R. H. Scott, Admiral Markham, Sir Vesey Hamilton, Sir W. White, Dr. Günther, Prof. Ray Lankester, Sir Michael Foster, Prof. Rücker, Prof. G. Darwin, Sir William Crookes, and a number of members of the Councils of the two Societies.

Sir Clements Markham, in introducing the deputation, laid great stress upon the scientific character of the proposed expedition. After bringing forward the historical argument of the interest taken by former Governments in polar exploration, and the value of navigation in those seas as a training for seamen and officers, he said (we quote the report in the *Times*):—

"Still the avowed object of Government expeditions was scientific research. The objects of the two societies were identical. They were undertaking work which successive generations of our statesmen and naval officers had looked upon as beneficial to the country and to the navy, and for this reason thought they had a claim on the Government for assistance. But further, some of the scientific results required were of immediate practical value. Indeed, all scientific research became eventually, directly or indirectly, practically useful. Much of the Antarctic work would, however, at once be of use to navigation, especially as regarded the magnetic survey."

Sir Joseph Hooker, the last survivor of the great Antarctic exploring voyage of the *Erebus* and *Terror*, under Sir James Ross, supported Sir Clements Markham, and Lord Kelvin followed with the hope that all would be done to bring the enterprise to a triumphant issue. Prof. Ray Lankester spoke of the importance of the biological observations, and especially referred to the question of a bi-polar fauna as one likely to be greatly elucidated by the expedition; and Prof. Rücker, in conclusion, pointed out how important the magnetic survey of the Antarctic area is.

Mr. Balfour replied in a sympathetic speech, in the course of which he said:—

"I, for my own part, fully recognise that if, as I think, expeditions to the poles of the earth, or towards the poles of the earth, are eminently desirable, both on practical and purely scientific grounds, these expeditions are perhaps even more important when undertaken towards the Antarctic Pole than towards the Arctic Pole, for we certainly know much less at present about the Antarctic regions than we do about the Arctic regions, and the actual area of this unknown but immense portion of the earth's surface is much larger in the case of the South Pole than in the case of the North Pole. . . . I, however, should not be representing my own personal convictions—and I am speaking in this matter for myself—if I for a moment let it be thought that in my judgment the scientific investigations which directly, immediately, and obviously lead to some practical result are the only ones which it is worthy of a great nation to pursue. I take a different view based partly upon the scientific experience of the world. If our forefathers of the last two centuries—I do not mean men of British origin alone, but I include the great French expeditions and other expeditions sent out during the last century and during the seventeenth century—had not carried on this work, it is manifest that our ignorance of the planet on which we live would be much more profound than it is at present; and it would not be creditable to an age which flatters itself, above all other ages, to be a scientific age, if without reluctance we acquiesced in the total ignorance which now envelops us of so enormous a portion of the southern hemisphere of our planet. For my own part, while I entirely agree with all that has been said upon the important facts and issues which may be anticipated from any expedition, I by no means limit my interest to such practical results. The things which we go directly to observe, and with every intention of observing, are doubtless of the highest importance. But I shall be greatly surprised if the expedition does not come across a great many phenomena which we did not expect, and which will throw a novel light upon many of the most important scientific theories, meteorological, geological, biological and magnetic. If this expedition is sent forth, as I hope it will be, adequately equipped at the date to our satisfaction, when we shall be able to co-operate with the German expedition, in respect of scientific interest alone such co-operation must be valuable from every point of view, and it will, among other things, have the effect of strengthening, if such strengthening be necessary or possible, the cosmopolitan or international character of these sciences. . . . I am sure if the Chancellor of the Exchequer were here to-day he would tell you that, in so far as he could meet the wishes of the deputation, such action on his part must be regarded not as a reason for giving something more to some future deputation, but rather as a reason for giving less. But with that caution, which I feel bound to utter on his behalf, I think I should not arouse undue hopes if I say that the Chancellor of the Exchequer will find it in his power to give substantially to the great project which you have in hand. I do not say that the aid given will reach the limits of your largest wishes, but I hope and believe that it will be sufficient to enable us to send out this expedition in a manner not unworthy either of the great societies which have interested themselves in this matter or of those liberal members of the public who have subscribed out of private means to further the object which you have in view, and not unworthy of the country which has done more than any other country in the past to send forth expeditions similar in character to the one which you desire to send forth."

Nothing could be more satisfactory than Mr. Balfour's view of the claims of research in pure science to public recognition, or his promise that a liberal grant to the Antarctic expedition shall be given by Government. It remains for the Joint-Committee to settle the plan of the expedition and to select the scientific leader on whose qualifications as a man of science and on whose freedom of action with regard to the executive authority of the ship or ships the success of the expedition as a scientific enterprise will entirely depend. This choice cannot be made too soon, for the details of scientific equipment must largely determine the plan of the ship which has to be built; and no one can be so well qualified to advise upon and carry out the preparations as the man whose reputation depends on the result of those scientific investigations which every one of the promoters of the expedition has declared to be its exclusive object.

## CHARLES WILLIAM BAILLIE.

We regret to have to announce the sudden death, at Broadstairs, on June 24, at the age of fifty-five years, of Naval Lieutenant Charles William Baillie, Marine Superintendent of the Meteorological Office, a post which he had held for eleven years.

Mr. Baillie was perhaps best known by his sounding machine, which he invented while on the North American Station about 1871, and which is still in use. It is a modification of the apparatus known as the "Hydra" machine. It was used in the *Challenger* expedition, and is described in Sir W. Thomson's book, "The Voyage of the *Challenger*." Lieut. Baillie was much employed in surveying, and while in the *Sylvia*, under Captain (now Vice-Admiral) St. John, on the China Station, he was selected by the Admiralty to be Director of Nautical Studies at the Imperial Naval College at Tokio, Japan. The results of his teaching are to be seen in the condition of the Japanese Navy at the present day.

After several years of duty in this important post he returned to England on half-pay. In October 1879 he joined the Meteorological Office, so that he had nearly completed twenty years of service in that institution.

The principal works which he has carried out there have been the charts of sea surface temperature, of barometrical pressure, and of currents for all oceans.

The discussion of the meteorology of the South Indian Ocean, from the Cape of Good Hope to New Zealand, which is shortly about to appear, has been carried out under Lieut. Baillie's superintendence, while he had laid down the lines of inquiry to be pursued in the work now n hand at the office—the "Meteorology of the South Atlantic and of the Coasts of South America." Lieut. Baillie was a Fellow of the Royal Geographical and the Royal Astronomical Societies. He married Miss Conyers, of Bermuda, and leaves a numerous family.

## NOTES.

Prof. W. C. Brögger, of the University of Christiania, has accepted an invitation to deliver the second course of the George Huntington Williams memorial lectures at the Johns Hopkins University, in April 1900. He has selected as his subject "Modern deductions regarding the origin of igneous rocks."

Dr. G. Agamennone has been selected to succeed the late Prof. M. S. de Rossi as director of the important Geodynamic Observatory at Rocca di Papa, near Rome. Dr. Agamennone, who is well known by his numerous seismological papers, has for several years been assistant at the Central Office of Meteorology and Geodynamics at Rome; and, during the years 1895–96, was in charge of the seismic department of the Meteorological Observatory at Constantinople.

News has been received of the death of Mr. John Whitehead while on a scientific mission in the Island of Hainan. Mr. Whitehead left England in the autumn of last year for the purpose of exploring the less known islands of the Philippine group and obtaining a collection of their fauna for the British Museum (Natural History).

We learn from *Science* that President McKinley has appointed a Commission to determine the best route for a canal across the Isthmus of Panama or Nicaragua. The sum of 1,000,000 dollars has been appropriated for the expenses of the Commission, and a number of surveyors will accompany the party which will shortly leave for Colon.

Dr. D. G. Brinton, Professor of American Archæology and Linguistics at the University of Pennsylvania, has presented to the University his entire collection of books and manuscript relating to the aboriginal languages of North and South America, representing the work of twenty-five years, and embracing about 2000 titles.

An excursion to Derbyshire, extending from August 3 to August 9, has been arranged by the Geologists' Association. The directors of the excursion are Mr. H. H. Arnold-Bemrose, Dr. Wheelton Hind, Mr. J. Shipman, and Mr. J. Barnes. A sketch of the geology of the Lower Carboniferous rocks of Derbyshire will be given by Mr. Arnold-Bemrose at a meeting of the Association on July 7.

The preliminary programme of the thirteenth International Medical Congress, to be held in Paris from August 2 to August 9, 1900, has just been issued from the central offices in the Rue de l'École de Médecine. M. Lannelongue is president of the Congress, and Dr. Chauffard is the secretary-general. National Committees have been formed in each country to further the work of the Congress. The president of the Committee for Great Britain is Sir William MacCormac, Bart., K.C.V.O., and the hon. secretaries are Dr. Garrod, Dr. Keser, and Mr. D'Arcy Power.

The second trade exhibition of photographic and scientific apparatus and sundries will be held in the Portman Rooms, on April 27 to May 5 next year. Intending exhibitors should communicate with the Secretary of the Exhibition, 15 Harp Alley, Farringdon Street, E.C.

To celebrate the centenary of the granting of the charter to the Royal College of Surgeons of England in 1800, the Council propose to apply for a supplementary charter. It is proposed to obtain powers to confer the Fellowship of the College on persons of distinction who are not members. A memorial has been drawn up, suggesting to the Council that a favourable opportunity now presents itself for the satisfaction of that desire which has at various periods during the century, and especially during the last fifteen years, been expressed by a large number of the members of the College—viz. that they should be represented on the Council. It is submitted that "it would be both equitable and politic that the members should have a voice in the conduct of a Corporation of which they are, and always have been, numerically and financially the mainstay." At every annual meeting of Fellows and members (instituted in 1884) this or some similar proposal has been carried practically unanimously, and a petition in its favour was signed by nearly 5000 members and presented to the Privy Council. The Council have twice taken a poll of the Fellows on the question, but on neither occasion has an absolute majority voted against the proposal, though many were in its favour.

The *Academy* invited its readers to compose an inscription, of not more than forty words, suitable to be engraved upon the statue of Charles Darwin, just unveiled at Oxford. The best inscription was considered to be that submitted by Mr. Edwin Cardross, viz.: "Charles Darwin, the great naturalist, memorable for his demonstration of the law of evolution in organic life, achieved by scientific imagination, untiring observation, comparison, and research: also for a blameless life, characterised by the modesty, 'the angelic patience, of genius.'"

An interesting survival of the very ancient custom of watching the sun rise at the summer solstice was witnessed on Salisbury Plain on June 21. The *Westminster Gazette* states that on the night preceding the longest day (June 21) there was a large gathering of people from the neighbourhood, and also from other parts, assembled close to the historic circle of stones at Stonehenge, in order to see the sun rise over the Plain. When atmospheric conditions are favourable, those watching

rom the altar stone in the centre of the circle see the sun apparently poise itself for an instant upon the top of the stone known as the Friar's Heel. This sight is a rare privilege, and as it depends upon a doubtful meteorological condition—a perfectly cloudless sky at the point and time at which the sun rises above the horizon—those watching anxiously scan the sky, alas ! in too many instances, to find that their night's vigil on the Plain is barren of result. The last time the phenomenon was witnessed was in 1895.

THE annual general meeting of the Jenner Institute of Preventive Medicine was held at Chelsea on June 23. The report of the Council for the year was read and adopted. The report states that during the year the work of the institute continued to make satisfactory progress. The internal fittings of the Chelsea building are now completed with the exception of the museum, and the various departments are fully equipped and at work. The meeting received with enthusiasm the reference to Lord Iveagh's gift of 250,000*l.* for the promotion of the objects for which the institute was founded. The gratifying announcement was made that Lord Lister had consented to act as chairman of the new governing body that will in future control the affairs of the institute. Dr. Macfadyen's report upon the general work of the institute during the year was read and adopted. During the year the organisation of work in the main laboratories of the institute was completed, and valuable additions made to the stock of scientific apparatus. The foundations of the new wing, which will complete the original plan of the institute, are at present in course of construction. The photographic department is fully equipped, and the necessary illustrations to scientific papers will in future be prepared in this laboratory. At no period has there been a greater body of research work in progress in the institute than at the present moment, and reference is made in the report to the more important investigations being carried on. A number of investigations by Dr. Hewlett and others have been published during the year, and a second volume of the *Transactions* of the institute is going through the press. As regards the courses of instruction, which have been well attended, the aim has been to train the advanced student, as is done in foreign laboratories, with a view to subsequent research work. A notable addition has been made to the departments of the institute by the foundation of the Hansen Laboratory for the study of the practical application of bacteriology to industrial and technical processes. Dr. G. Harris Morris has been placed in charge of this department, which is now at work. Dr. A. Harden's report deals with the work of the chemical and water laboratory during the year. Dr. G. Dean's report on the antitoxin department describes the improved methods adopted for the preparation of diphtheria anti-toxin and the researches being carried out in connection with tetanus, pneumonia, anti-streptococcic serum, &c.

AT the suggestion of Prof. E. Ray Lankester, Lieut. A. G. Froud has sent us a copy of a report, by Mr. G. T. Prior, upon some fine brown dust collected on board the P. and O. s.s. *Sumatra* during a thunderstorm in the Galita Channel, Mediterranean. The dust contained about 33 per cent. of doubly refractive grains, composed chiefly of carbonates of calcium, magnesium, and iron. After treatment with hydrochloric acid, the insoluble residue was for the most part without influence on polarised light, and consisted mainly of silicate of alumina (clay), with a little organic matter ; only a few angular grains of quartz, and one or two very strongly refractive and doubly refractive grains, probably of iron, were observed in this insoluble residue. The dust was thus of the nature of an argillaceous and calcareous sand, and may have been carried by wind from the north of Africa. In his report, Mr. Prior remarks :—"An account by C. V. John, with analysis of fine brown dust which fell in Hungary in February 1896, will be found in *Verh. Geol. Reichsanst.* (ix., 1896, pp. 259-64). This dust, like the above, was characterised by the almost total absence of quartz, and by the presence of grains of transparent amorphous clay material. It differed from the above, however, in not containing any large amount of carbonates. The similarity in chemical composition of this Hungarian dust with that of Nile mud is pointed out, and the suggestion is made that the dust may have been derived from Egypt."

DR. MOTTE, naturalist, 13 rue Royale, Lyons, informs us that the family of a deceased collector have an egg of the Great Auk (*Alca impennis*) among other ornithological objects they desire to sell.

A FEW interesting facts with regard to the kea, or sheep-eating parrot, of New Zealand are related in the July number of the *Leisure Hour* by Dr. F. Truby King. The intense curiosity of these birds is stated to be sufficient to account for the habit of eating sheep acquired by them. Dr. King thinks it is probably a mistake to suppose that the kea designedly makes at once for the kidney fat of the sheep upon which it has pounced. It eats into various parts of the body, though perhaps more often into the region of the kidney, as it is there that the kea gets the firmest stand on the back of the running sheep. This view is strengthened by the fact that the bird prefers double-fleeced sheep—that is, such as have remained a whole season unshorn, on which it obtains a firmer grip.

IN an article on the Gold Measures of Nova Scotia (Canadian Mining Inst., March), Mr. E. R. Faribault remarks that the workable deposits of free gold are confined to the metamorphic rocks of the Atlantic coast, and occupy an area of about 5000 square miles. The gold-bearing rocks are intersected by dykes and large masses of granite which have no connection with the auriferous veins. It is observed, however, that all the rich veins and the large bodies of low grade quartz, with few exceptions, follow the planes of stratification, and occur at well-defined points along the anticlinal axes of the folds. The rocks are regarded as of Lower Cambrian age.

DR. HEPITES, director of the Meteorological Institute of Roumania, has communicated to *Ciel et Terre* of March 1 an interesting summary of the climatology of the Roumanian coast of the Black Sea. Thanks to the observations persistently made by the European Commission of the Danube, there is an uninterrupted series of observations for twenty-two years at Soulina and another series of thirteen years at Constantza, made under the superintendence of the institute. The temperature of the air at both these places is nearly similar ; the yearly mean at the latter place is 51°·8. The highest shade temperature was 97°·2 in July, and the lowest −5°·3 in January. The extreme temperatures recorded in other parts of Roumania are 108° at Giurgevo in July 1896, and −32°·1 in January 1893. The rainfall on the coast is comparatively small, the average annual amount at Constantza is 15·7 inches. It is very seldom that the rainfall in any one year exceeds 20 inches ; at Soulina during the last thirty years it has twice exceeded 23 inches. Rain falls on an average on 76 days in the year, and is spread fairly equally throughout all the months ; snow falls on an average during 12 days in the year.

THE thirteenth volume (for 1897) of the *Analele* of the Meteorological Institute of Roumania has recently been published. In his annual report, the director, Dr. S. C. Hepites, who is now retiring after thirty years of service to the State, gives a history of the meteorological service during the first thirteen years of its working. In 1883 there were only three

meteorological, and ten pluviometric, stations in the whole country. There are now a meteorological station of the first order at Bucharest, thirty-eight of the second order, one of the third, and 327 pluviometric stations within an area of 131,400 sq. km. The annual volume, which in the present case contains nearly 800 quarto pages, bears testimony to the value of the work accomplished. Besides the usual meteorological tables, it contains an account of the new magnetic observatory at Bucharest by M. St. Murat, and nine other memoirs, among which may be mentioned those by the director on rain at Bucharest during the last thirty-two years, the rainfall of Roumania in 1897, the magnetic elements of Bucharest, and on the register of earthquakes, eleven in number, felt during the year 1897.

IN the columns of NATURE last autumn, attention was directed by several writers to the phenomenon well known amongst iron-workers that if a bar of steel or iron, heated to a red or white heat at one end, have that end suddenly plunged into cold water, the other end will appear to become hotter. Prof. E. Lagrange, writing in the *Bulletin* of the Belgian Academy (1899, No. 4), describes experiments showing that this effect is quite compatible with the ordinary laws of conduction of heat. The bar in every case is removed from the fire before the stationary point has been reached; the temperature of the unheated end is increasing at the time of removal, and as its rate of change does not vary discontinuously, it continues to increase after removal. When the hot end of the bar is suddenly cooled, Prof. Lagrange finds that the other end attains its maximum temperature sooner, and this maximum is considerably lower than when the hot end is cooled slowly. If, however, the bar is heated until the flow of heat has become steady, no further increase takes place at the other end, whether the hot end is cooled slowly or suddenly, but the unheated end begins to cool at once, and its cooling is more rapid in the second than in the first case.

WHETHER corresponding to the Zeeman effect there exists the reciprocal phenomenon of the production of a magnetic field by a circularly polarised ray has been discussed by Profs. Fitzgerald and Gray in NATURE for January 5 and February 16. Prof. Augusto Righi, writing in the *Atti dei Lincei*, viii. (1), 7, describes his own experiments on the subject. Prof. Righi used columns of vapour of hypo-azotide and of bromine, the illumination being produced by a plane polarised beam of sunlight, between which and the tube two quarter-wave laminæ of quartz oppositely turned were placed. An astatic magnetometer showed no deviation either when the sense of polarisation was reversed by interchanging the quartzes or when the light was cut off, although a magnetic field of $10^{-6}$ C.G.S. units produced a perceptible deviation. In another note, published in the *Rendiconto* of the Bologna Academy, Prof. Righi describes his determination of the rotatory power of chlorine in a magnetic field. The numerical measure of this effect referred to bisulphide of carbon was found to be 0·000337, and chlorine is thus intermediate between carbonic anhydride and protoxide of nitrogen, whose rotatory powers, as found by Becquerel, are 0·000302 and 0·000393 respectively.

FROM a paper published by Drs. Rabinowitsch and Kempner in the *Zeitschrift für Hygiene* on the milk of tuberculous cows, the chance of infection from the latter appears to be greater than was even supposed. Whereas it has been generally found that cow's milk only contains tubercle bacilli when the udder is affected, or when the animal is in an advanced stage of tuberculosis, the above authors have found the bacilli in milk in the very beginnings of the disease, and without any udder affection, as well as in latent cases where its existence could only be verified by the tuberculin test. The authors point out that it is not sufficient to make one examination only of the milk, and they cite an instance in which, whilst the milk gave a negative result, butter made from the milk derived from the same cow on the same day on inoculation into guinea-pigs resulted in the death of the latter from tuberculosis, whilst an examination of this cow's milk made at a later date revealed the presence of tubercle bacilli. In view of these investigations, the authors are of opinion that the milk of all cows which react to the tuberculin test ought to be regarded with suspicion, and they point out, moreover, the great value which attaches to this test in helping to obtain milk-supplies free from the contagion of tuberculosis.

IT is always with pleasure that we receive a new *Bulletin* o the Madras Government Museum, as we are sure to find therein brightly written and instructive papers on the native races of Southern India by Mr. Edgar Thurston, the superintendent of the Museum. The most important of these little memoirs in the last issue (vol. ii. No. 3) is one on the Kadirs of the Anaimalai Hills. They are a dark-skinned, curly-haired people, short in stature (average 1·577) with a broad span (1·688), deep-chested, and like many mountaineers they rarely walk with a straight leg. The head is narrow (average 72·9), the jaws do not project, and the nose is wide (average 89·8). They thus are good representatives of the ancient population of Southern India. They have one remarkable custom which appears to be unique in the Indian peninsula, and that is the chipping of all or of some of the incisor teeth of both jaws into the form of a sharp-pointed cone.

IN a note on the Dravidian head, Mr. Thurston (*loc. cit.*) states that the average cephalic index of 639 Dravidians belonging to nineteen tribes and castes is 74·1. Out of the total number measured by him only nineteen, or 3 per cent., of the indices exceeded 80, the maximum being 83·7. In a discussion on the Dravidian problem, Mr. Thurston gives only a few original observations, and has collected the opinions of a number of authors, but he does not sum up or give us his own conclusions.

THE origin of life, as developed from a mechanical foundation, forms the subject of a work by Dr. Ludwig Zehnder, of Freiburg, the first part of which has just reached us. After referring to the work of Darwin and his successors, the author tells us in his introduction that there has long been a hope that a direct transition between unorganised and organised bodies would some day be discovered, but that hitherto the gap has not been bridged. Apparently it is his intention to show how the two great groups are at present known to approach one another. The present part treats of Monads, simple cells, and Protistæ.

IN broad contrast to the foregoing may be mentioned a brief paper by M. E. Lefort, published at Lyons under the title of "Fausseté de l'Idée Evolutioniste appliquée au Système Planétaire ou aux Espèces Organiques." The general contention appears to be that every change in nature is due to direct Divine interposition.

A SHORT account of the first voyage of the Prince of Monaco's new vessel, *Princess Alice II.*, appears in the *Comptes rendus*; and a fuller description of the work in northern waters, illustrated by photographs, is published in the Paris *Bulletin du Muséum d'histoire naturelle*. The expedition of last year started from Havre in June, and, after a meeting with the Emperor of Germany off the Norwegian coast, worked in Spitsbergen waters till the end of August, returning to Havre about the middle of September. Extended physical and biological observations were made both at sea and on a number of islands in high northern latitudes. The collections

will be added to the museum of oceanography recently founded by the Prince at Monaco.

WE have received the first number of *Finland*, an "English journal devoted to the cause of the Finnish people."

*Science* of June 16 publishes a translation of a criticism of the plans for an International Catalogue of Scientific Literature, contributed to the *Zoologische Anzeiger* by Prof. J. Victor Carus.

A MEETING of the Anatomical Society of Great Britain and Ireland will be held in the Anatomical Schools, New Museums, Cambridge, on Saturday, July 8, commencing at 2 p.m.

MESSRS. J. AND A. CHURCHILL announce that they will shortly publish the following scientific works: A text-book of physics by Prof. Andrew Gray, F.R.S.; the book will be issued in three parts, the first to appear being that on dynamics and properties of matter. A work on medical electricity for the use of students and practitioners, by Dr. W. S. Hedley. A handbook on chemistry and physics, for students preparing for the first examination of the Conjoint Board, by Messrs. Corbin and Stewart.

THE additions to the Zoological Society's Gardens during the past week include a Rhesus Monkey (*Macacus rhesus*, ♀) from India, presented by Mrs. L. Smallcombe; a Macaque Monkey (*Macacus cynomolgus*) from India, presented by Mr. J. H. Johnston; a Diana Monkey (*Cercopithecus diana*, ♀) from West Africa, presented by Mr. T. N. Loy; a —— Deer (*Cariacus*, sp. inc. ♂) from Tobago, presented by Captain J. Leslie Burr, R.N.; a Stone Curlew (*Aedicnemus scolopax*), European, presented by Mr. D. T. Campbell; six Cormorants (*Phalacrocorax carbo*, juv.) from Scotland, presented by Mr. Percy Leigh Pemberton; a Yellow-crowned Penguin (*Eudyptes antipodum*), a Thick-billed Penguin (*Eudyptes pachyrhynchus*) from New Zealand, a Rock-hopper Penguin (*Eudyptes chrysocome*) from the Falkland Islands; two Elephantine Tortoises (*Testudo elephantina*) from the Aldabra Islands, a Reticulated Python (*Python reticulatus*) from the East Indies, deposited; a Red Deer (*Cervus elaphus*, ♂), born in the Gardens; two Coscoroba Swans (*Coscoroba candida*) from Antarctic America, purchased.

## *OUR ASTRONOMICAL COLUMN.*

ASTRONOMICAL OCCURRENCES IN JULY:—

July 2. 9h. 16m. to 11h. 14m. Transit of Jupiter's Sat. III.
3. 12h. 40m to 13h. 30m. Occultation of the star D.M. + 21°, 539 (mag. 5·7) by the moon.
3. 14h. 57m. to 15h. 43m. Occultation of the star 32 Tauri (mag. 5·7) by the moon.
5. 15h. Conjunction of Venus and the moon (♀ 1° 0′ south).
6. 10h. Conjunction of Venus and Neptune (♀ 0° 46′ north).
13. 9h. 51m. Minimum of Algol (β Persei).
15. Venus. Illuminated portion of disc 0·955, Mars 0·931.
19. 8h. 6m. to 9h. 17m. Occultation of B.A.C. 5709 (mag. 6·3) by the moon.
19. 8h. 9m. to 9h. 24m. Occultation of 26 Ophiuchi (mag. 6·1) by the moon.
19. 14h. Conjunction of Saturn and the moon (♄ 2° 26′ north).
20. 7h. 39m. to 8h. 41m. Occultation of 7 Sagittarii (mag. 5·4) by the moon.
20. 8h. 4m. to 9h. 15m. Occultation of 9 Sagittarii (mag. 5·7) by the moon.
21. 23h. Mercury at greatest elongation (26° 59′ east).
24. 9h. 26m. Jupiter's Sat. IV. in conjunction with north pole of planet.
28. Tempel's comet (1873 II.) in perihelion.

TEMPEL'S COMET 1899 *c* (1873 II.)—The following ephemeris is contributed to the *Astr. Nach.* (Bd. 149, No. 3574), by M. L. Schulhof.

*Ephemeris for 12h. Paris Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ ″ | Br. |
|---|---|---|---|
| June 29 ... | 20 13 33·4 ... | − 8 35 52 ... | 2·525 |
| 30 ... | 14 51·3 ... | 8 56 1 | |
| July 1 ... | 16 8·8 ... | 9 16 56 | |
| 2 ... | 17 25·9 ... | 9 38 37 | |
| 3 ... | 18 42·5 ... | 10 1 5 ... | 2·770 |
| 4 ... | 19 58·6 ... | 10 24 18 | |
| 5 ... | 21 14·4 ... | 10 48 17 | |
| 6 ... | 20 22 29·7 ... | −11 13 0 | |

FIFTH SATELLITE OF JUPITER.—In *Bulletin* No. 10 of the Yerkes Observatory (*Astrophysical Journal*, vol. ix., p. 358), Prof. G. E. Hale gives the measures of Jupiter's fifth satellite which have recently been made by Prof. E. E. Barnard with the 40-inch refractor. The observations were made on five nights during March and April 1898, and on four nights during April and May 1899. The constants determined are as follows:—

| Times of east elongation, G.M.T. d. h. m. | East elongation distance. ″ |
|---|---|
| 1898 March 2 18 57·80 ... | ... ... |
| 1898 March 6 18 36·11 ... | ... ... 48·14 |
| 1898 April 5 ... ... | ... ... 48·12 |
| 1899 April 25 19 5·26 ... | ... ... 48·34 |
| 1899 May 1 18 32·72 ... | ... ... 48·29 |

The different values of the elongation distance are due to the revolution of the line of apsides, which, as Tisserand showed, takes place in a period of five months. The consistency of the measures with the instrument are shown by the plotted curve of the 131 observations of May 1, none of which depart more than 0″·4 of arc from the mean.

The great number of revolutions made by the satellite since its discovery in 1892 render possible an accurate calculation of its period. Using the elongations of September 10, 1892, March 6, 1898, April 25, 1899, and May 1, 1899, the resulting periodic time is found to be

11h. 57m. 22·647s.

OXFORD UNIVERSITY OBSERVATORY.—The twenty-fourth annual report of the Savilian Professor contains an account of the work accomplished from June 1, 1898, to May 31, 1899, and a survey of the condition of the instrumental equipment. The large dome, erected in 1875, has become so defective that plans for a new one have been prepared, the estimated cost being 440*l*. In consequence of disadvantages resulting from the unprotected state of the observatory, the need of a residence is strongly urged. During the year the observatory has been greatly enriched by the acquisition of the library of the late Mr. George Knott. Among the numerous presents received, special mention is made of a long series of early nautical almanacs, extending from 1767 to 1843, kindly given by Mr. Robert Gordon.

The De la Rue astrographic telescope is in good order, 258 plates for the catalogue having been taken during the year. The De la Rue reflector and the Barclay transit circle are both in good order. With the latter an unknown, variable change of collimation error has been traced to the looseness of the object-glass in its cell, this being finally eliminated by cotton wool packing.

No time has been found to proceed further with the photographic transit circle. The four micrometers for measuring the catalogue plates are in general use, one being in charge of Mr. T. J. Moore, of Doncaster, who has measured 61,186 stars with it.

The staple work of the observatory staff has been the measurement and reduction of the plates for the astrographic catalogue, and about half of this is now done, 586 plates out of the 1180 allotted to the observatory having been measured, and 525 completely reduced. In the region of the Milky Way the times of exposure for the plates have been reduced to 3 min., 1 min. and 20 secs., the number of stars even with the smaller exposure being still over 300.

Considerable interest attaches to the investigation undertaken to determine the possible distortion present in a large photographic doublet. Positives from plates taken with the 24-inch Bruce doublet at Arequipa have been lent by Prof. Pickering,

and the results of their examination prove that it is possible to get large fields sensibly free from optical distortion. This has a most important bearing on the carrying out of the "chart" work, as it is at present necessary to expose for one hour to obtain a region $2^{\circ} \times 2^{\circ}$, whereas the new form of lens would give a much larger region in the same time. For this reason, Prof. Turner has indefinitely postponed the taking of the "chart" plates for the Astrographic Survey.

Cambridge Observatory.—Embodied in the *Cambridge University Reporter* for June 16, is the annual report of the Cambridge Observatory from 1898 May 26 to 1899 May 25. With the meridian circle, 2241 observations of 1420 stars have been taken, most of these being repetitions of previous observations for the catalogue.

One hundred and seventy-six observations have been made of the Harrow occultation stars; and, at the request of Dr. Gill, observations of heliometer comparison stars were commenced in March and are still in progress.

In addition, there have been other measurements of standard stars, bringing up the total number of meridian observations to 3616.

The new bent equatorial, to be called the "Sheepshanks equatorial" (see illustrated description in *Monthly Notices*, R.A.S., 1899 January, vol. lix. p. 152) was completed about September 1898, and its adjustment was undertaken by Mr. Hinks. It was soon found that the objective tube had a large flexure, and a new tube is being made. The first trial photographs were unsatisfactory, the disturbing cause being thought to be the air currents in the tube, which is partly open near the joint.

The Newall telescope has been employed on 96 nights during the year, in connection with the Bruce spectroscope, in taking photographs of stellar spectra for determining their velocity in the line of sight; 150 photographs have been obtained, giving material for determining the velocity of 60 stars. Thirty of these are included in the Potsdam list of 51 stars observed from 1888-1891. Preparations are in hand for converting the spectroscope into a powerful 4-prism instrument for detailed examination of a few of the brightest stars. Special series of stellar spectra have been taken to assist in the reduction of the eclipse photographs obtained in India in 1898. For this purpose also attempts have been made to separate scandium salts from the mineral gadolinite.

## *PICTURES PRODUCED ON PHOTOGRAPHIC PLATES IN THE DARK.*[1]

I think I may fairly assume that every one in this theatre has had their photograph taken, and consequently must have some idea of the nature of the process employed. I have, therefore, only to add, with regard to what is not visible in the process of taking the picture, that the photographic plate is a piece of glass or such like body, coated on one side by an adhesive paste which is acted on by light, and acted on in a very remarkable manner. No visible change is produced, and the picture might remain latent for years, but place this acted on plate in a solution, of, say pyrogallol, and the picture appears. The subsequent treatment of the plate with sodium hyposulphite is for another purpose, simply to prevent the continuance of the action when the plate is brought into the light. Now, what I purpose demonstrating to you to-night is that there are other ways of producing pictures on photographic plates than by acting on them by light, and that by these other means a latent picture is formed, which is rendered visible in precisely the same way as the light pictures are.

The substances which produce on a photographic plate these results, so strongly resembling those produced by light, are, some of them, metallic, while others are of vegetable origin. At first it seemed very remarkable that bodies so different in character should act in the same way on the photographic plate. The following metals—magnesium, cadmium, zinc, nickel, aluminium, lead, bismuth, tin, cobalt, antimony—are all capable of acting on a photographic plate. Magnesium most strongly, antimony but feebly, and other metals can also act in the same way, but only to a very slight extent. The action in general is much slower than that of light, but under favourable conditions a picture may be produced in two or three seconds.

[1] A lecture delivered at the Royal Institution on Friday, May 5, by Dr. W. J. Russell, V.P.R.S.

Zinc is nearly as active as magnesium or cadmium, and is the most convenient metal to experiment with. In its ordinary dull state it is entirely without the power of acting on a photographic plate, but scratch it or scrape it, and it is easy to prove that the bright metal is active. I would say that all the pictures which I have to show you, by means of the lantern, are produced by the direct action of the metal, or whatever the active body may be, on the photographic plate, and that they have not been intensified or touched up in any way. This first slide is the picture given by a piece of ordinary zinc which has been rubbed with some coarse sand paper, and you see the picture of every scratch. Here is a piece of dull zinc on which some circles have been turned. It was exposed to the photographic plate for four hours at a temperature of 55° C. In the other cases, which are on a larger scale, a zinc stencil was polished and laid upon a photographic plate, and you see where the zinc was in contact with the plate much action has occurred. In the other case a bright zinc plate was used, and a Japanese stencil interposed between it and the photographic plate, and a very strong and sharp picture is the result. The time required to produce these zinc pictures varies very much with the temperature. At ordinary temperature the exposure would have to be for about two days, but if the temperature was, say, 55° C., then half to three-quarters of an hour might be sufficient. Temperatures higher than this cannot be used except for very short times, as the photographic plate would be damaged. Contact between the zinc and photographic plate is not necessary, as the action readily takes place through considerable distances. Obviously, however, as you increase the distance between object and plate, so you decrease the sharpness of the picture, as is shown by the following pictures, which were taken respectively at a distance of 1 mm. and 3 mm. from the scratched zinc surface. The appearance of the surfaces of different metals varies, and the following slides show the surface of a plate of bismuth, a plate of lead, and one of aluminium. On the next slide are the pictures produced by similar pieces of pure nickel and cobalt, and it clearly shows how much more active in this way nickel is than cobalt. Many alloys, such as pewter, fusible metal, brass, &c., are active bodies, and in the case of brass the amount of action which occurs is determined by the amount of zinc present. Thus you will see that a brass with 30 per cent. of zinc produces hardly any action on the photographic plate, but when 50 per cent. of zinc is present there is a fairly dark picture, and when as much as 70 per cent. is present a still darker picture is produced. The second class of bodies which act in the same way on a photographic plate are organic substances, and belong essentially to the groups of bodies known as terpenes. In trying to stop the action of metallic zinc, which I thought at the time might arise from vapour given off by the metal, copal varnish was used, but in place of stopping the action it was found to increase it, and this increase of activity was traced to the turpentine contained in the varnish. In experimenting with liquids it is convenient to use small shallow circular glass vessels such as are made for bacteriological experiments, the plate resting on the top of the vessel, and the amount of liquid in the vessel determining the distance through which the action shall take place. The following slide, produced in this way, shows how dark a picture ordinary turpentine produces. All the terpenes are active bodies. Dipentine is remarkably so; in a very short time it gives a black picture, and if the action be continued, the dark picture passes away, and you then have a phenomenon corresponding to what photographers call reversal. The strong smelling bodies known as essential oils, such as oil of bergamot, oil of lavender, oil of peppermint, oil of lemons, &c., are all active bodies, and all are known to contain in varying quantities different terpenes; therefore ordinary scents are active bodies, and this is shown by the following pictures produced by eau de Cologne, by cinnamon, by coffee, and by tea. Certain wines also act in the same way, Sauterne gives a tolerably dark picture, but brandy only a faint one. Other oils than these essential ones are also active bodies; linseed oil is especially so; olive oil is active, but not nearly as much so as linseed oil; and mineral oils, such as paraffin oil, are without action on the photographic plate.

Interesting results are obtained with bodies which contain some of these active substances; for instance, wood will give its own picture, as is shown by the following slides: the first is a section of a young spruce tree, the next a piece of ordinary deal, and the third of an old piece of mahogany. Again, the

next slide you will recognise as the picture of a peacock's feather. There is much interest in these pictures of feathers, as they distinguish the brilliant interference colours from those produced by certain pigments; the beautiful blue in the eye of the peacock's feather is without action on the photographic plate. Butterflies' wings, at least some of them, will draw, as you see, their own pictures. Linseed oil, which is a constituent of all printing ink, makes it an active body, and it can, like the zinc and other active bodies, act through considerable distances. In the picture before you the ink was at a distance of one inch from the plate, and the next slide shows what a remarkably clear and dark picture ordinary printing can produce. As the composition of printing ink varies so does its activity, and here are pieces of three different newspapers which have acted under the same conditions on the same plate, and you see how different the pictures are in intensity. Printed pictures, of course, act in the same way; here is a likeness of Sir H. Tate taken from "The Year's Art." The pictures and printing in *Punch* always print well, so does the yellow ticket for the Friday evening lectures at the Royal Institution; also the rude trade-mark on Wills's tobacco, and it is of interest because the red pigment produces a very clear picture, but the blue printing is without action on the plate.

An interesting and important peculiarity of all these actions is that it is able to pass through certain media; for instance, through a thin sheet of gelatin. Here are two plates of zinc; both have been scratched by sand-paper; one is laid directly on the photographic plate, and the other one has a sheet of gelatin, its colour is of no note, laid between it and the sensitive plate; the picture in this case is, of course, not so sharp as when no gelatin is present, but it is a good and clear likeness of the scratches.

Celluloid is also a body which allows the action to pass through it, as is seen in this picture of a piece of perforated zinc, a picture which was produced at ordinary temperatures. Gold-beaters' skin, albumen, collodion, gutta-percha, are also bodies which are transparent to the action of the zinc and the other active bodies. On the other hand, many bodies do not allow the transmission of the action through them; for instance, paraffin does not, and among common substances writing ink does not, as is easily shown by placing ordinary paper with writing on it between the active body and the photographic plate. The active body may conveniently be either a plate of zinc or a card painted with copal varnish and allowed to dry, or a dish of drying oil. The picture of an ordinarily directed envelope shows this opacity of ink well. It is a property long retained by the ink, as this picture of the direction of a letter, written in 1801, shows; also this letter of Dr. Priestley's, dated 1795, and here is also some very faded writing of 1810, which still gives a very good and clear picture. Even if the writing be on parchment, the action passes through the parchment, but not through the ink, and hence a picture is formed.

With bodies which are porous, such as most papers, for instance, the action passes gradually through the interstices, and impresses the plate with a picture of the general structure of the intervening substance. For instance, the following pictures show the structure and the water-mark of certain old and modern writing papers. Some modern writing papers are, however, quite opaque; but usually paper allows the action to take place through it, and combining this fact with the fact of the strong activity of the printing ink, the apparently confused appearance produced on obtaining a picture from paper with printing on both sides is accounted for, as the printing on the side away from the photographic plate, as well as that next to it, prints through the paper, and is, of course, reversed.

I hope I have now given you a clear idea how a picture can be produced on a photographic plate in the dark, and the general character and appearance of such pictures. I now pass on to the important question of how they are produced. Moser suggested fifty years ago that there was "dark light," which gave rise to pictures on polished metallic plates, and lately it was suggested that pictures were produced by vapour given off by the metals themselves; the explanation, however, which I have to offer you is, I think, simpler than either of these views, for I believe that the action on the photographic plate is due to the formation of a well-known chemical compound, hydrogen peroxide, which undergoing decomposition acts upon the plate and is the immediate cause of the pictures formed. The complicated changes which take place on the sensitive plate I have nothing to say about on the present occasion, but I desire to convince you that this body, hydrogen peroxide, is the direct cause of these pictures produced in the dark. Indirect proof has to be resorted to. Water cannot be entirely excluded, for an absolutely dry photographic plate would probably be perfectly inactive, and as long as water is present peroxide of hydrogen may be there also. But what are the conditions under which these pictures are formed? Only certain metals are capable of producing them. This list of active metals which I have mentioned to you was determined solely by experiment, and when completed it was not evident what common property bound them together. Now, however, the explanation has come, for these are the very metals which most readily cause, when exposed to air and moisture, the formation of this body, peroxide of hydrogen. Schönbein showed as long ago as 1860 that when zinc turnings were shaken up in a bottle with a little water hydrogen peroxide was formed, and the delicate tests which we now know for this body show that all the metals I named to you not only can in the presence of moisture produce it, but that their power of doing so follows the same order as their power of acting on a photographic plate. Again, what happened with regard to the organic bodies which act on the photographic plates? I have already mentioned that in experimenting with the metals it was accidentally observed that copal varnish was an active substance producing a picture like that produced by zinc, and that the action was traced to the turpentine present; again, a process very much like groping in the dark had to be carried on in order to determine which were active and which inactive organic bodies, and the result obtained was that the active substances essentially belonged to the class of bodies known to chemists as terpenes. Now a most characteristic property of this class of bodies is that in presence of moisture and air they cause the formation of hydrogen peroxide, so that whether a metal or an organic body be used to produce a picture, it is in both cases a body capable, under the circumstances, of causing the formation of hydrogen peroxide. Passing now to experimental facts, which confirm this view of the action on sensitive plates, I may at once say that every result obtained by a metal or by an organic body can be exactly imitated by using the peroxide itself. It is a body now made in considerably quantity, and sold in solution in water. Even when in a very dilute condition it is extremely active. One part of the peroxide diluted with a million parts of water is capable of giving a picture. It can, of course, be used in the glass dishes like any other liquid, but it is often convenient not to have so much water present; and then it is best to take white blotting-paper, wet it in the solution of the peroxide, and let it dry in the air. The paper remains active for about twenty-four hours; or, what is still better, take ordinary plaster of Paris, wet it with the peroxide solution, and let it set "in a mould" so as to get a slab of it. This slab increases in activity for the first day or two after making, and retains its activity for a fortnight or more. Such a slab will give a good and dark picture in three or four seconds.

To show how similar the pictures produced by the peroxide and those by zinc are, pictures of a Japanese paper stencil, which had been paraffined to make it quite opaque, have been made by both processes, and are shown with other instances in which turpentine was used in the following slides. It is also very easy to obtain good pictures with the peroxide alone of the structure of paper, &c.; see, for instance, this one of a five-pound note and these of lace. Again, the strict similarity between the action of the peroxide and that of the metals and organic bodies is further shown by the fact that its action passes through the same media as theirs does; and here are good pictures formed by the action of the peroxide after passing through a sheet of these substances. How this singular transmission can be explained, I have treated of elsewhere, and time does not allow of my discussing the matter to-night.

There are many ways in which the bright, active zinc surface can be modified. Draw your finger across it, press your thumb upon it, and you stop its activity, as is shown by the picture it will give. Lay a printed paper on the zinc, and let the contact continue for three-quarters of an hour, at a temperature of 55°, then bring the zinc in contact with a sensitive plate, a picture of the printing is formed, but allow the contact between the zinc and printing to continue for eighteen hours at the same temperature, and the picture then given by the zinc is the reverse of the former one. Where the ink has been is now less active than the rest of the plate. Here are slides which show these positive and negative pictures. Another way of modifying the zinc surface

is interesting. You have seen that the ordinary zinc surface which has been exposed to air and moisture is quite inactive, but if a bright piece of zinc be immersed in water for about twelve hours, the surface is acted on; oxide of zinc is formed, showing generally a curious pattern. Now, if the plate be dried, it will be found that this oxide is strongly active, and gives a good picture of the markings on the zinc. The oxide evidently holds, feebly combined or entangled in it, a considerable quantity of the hydrogen peroxide, and it requires long drying or heating to a high temperature to get rid of it. Also, if a zinc plate be attacked by the hydrogen peroxide, the attacked parts become more active than the bright metal. Thus, place a stencil on a piece of bright zinc, and expose the plate to the action of an active plaster of Paris slab, or to active blotting-paper for a short time, then, on removing the stencil, the zinc plate will give a very good picture of the stencil. Any inactive body—for instance, a piece of Bristol board or any ordinary soft paper—can be made active by exposing it above a solution of peroxide, or, more slowly, by exposing it to a bright zinc surface. If, for instance, a copper stencil be laid on a piece of Bristol board, and a slab of active plaster of Paris be placed on the stencil for a short time, the Bristol board will even, after it has been removed from the stencil for some time, give a good picture of the stencil. Drying oil and other organic bodies may be used in the same way to change the paper. A curious case of this occurred in printing a coloured advertisement cut out of a magazine, for there appeared printing in the picture which was not in the original. This printing was ultimately traced to an advertisement on the opposite page, which had been in contact with the one which was used; thus this ghostly effect was produced.

I believe, then, that it is this active body, hydrogen peroxide, which enables us to produce pictures on a photographic plate in the dark. There are many other curious and interesting effects which it can produce, and which I should like to have shown you, had time permitted.

I would only add that this investigation has been carried on in the Davy-Faraday laboratory of this institution.

WILLIAM J. RUSSELL.

## THE ROYAL SOCIETY'S CONVERSAZIONE.

THE second of the two annual conversazioni of the Royal Society was held on Wednesday, June 21, and was attended by a large and brilliant company. Many of the objects of scientific interest exhibited in the various rooms of the Society were the same as were shown at the first (or gentlemen's) conversazione held on May 3, the most important of which were described in NATURE of May 11 (p. 44). In addition to the objects already referred to, the following were among the exhibits.

Mr. C. V. Boys, F.R.S., exhibited for Mr. R. W. Wood, of the University of Wisconsin:—(1) Silvered photographic grating. The grating of 2,000 lines to the inch is a contact print on albumen. It is then silvered and polished while wet. The brilliancy of the spectrum is very great. (2) Diffraction colour photograph (see p. 199). Mr. J. E. Petavel exhibited the molten platinum standard of light.

Mr. W. A. Shenstone, F.R.S., and Mr. W. T. Evans showed experiments on the making of tubes from rock crystal in the oxyhydrogen blowpipe flame.

The Parsons Marine Steam Turbine Co., Ltd., had on view: (1) model of the *Turbinia*, the first vessel propelled by steam turbine engines; (2) model of torpedo boat destroyer of 35 knots guaranteed speed and 10,000 I.H.P.; (3) model of Atlantic liner of 38,000 I.H.P. and 27 knots speed.

Mr. A. A. Campbell Swinton showed experiments with electrolytic contact breakers. Mr. J. W. Swan, F.R.S., exhibited experiments showing effects produced by the action of modifications of the Wehnelt-Caldwell interrupter. Mr. W. R. Pidgeon showed a new influence machine. Mr. Mackenzie Davidson exhibited an apparatus to enable Röntgen ray shadows upon a fluorescent screen to be seen in stereoscopic relief.

Prof. Ray Lankester, F.R.S., exhibited (1) collections of mosquitoes recently received at the Natural History Museum for study in reference to the connection of malaria with mosquitoes; (2) drawings of mosquitoes, by Mr. Ernest E. Austen.

Dr. Patrick Manson showed microscopic specimens showing the development of the parasite of malaria.

Dr. Allan Macfadyen, for the Jenner Institute of Preventive Medicine, exhibited cultures and microscopical specimens of certain pathogenic bacteria.

Dr. Gladstone, F.R.S., showed ancient metals from Egypt, Babylon, and Britain.

The Victoria and Albert Museum for the Seismological Committee of the British Association exhibited a Milne horizontal-pendulum seismograph, with specimen of the seismograms yielded by it.

Prof. Haddon, F.R.S., showed a small collection of polished stone implements from the Baram District, Sarawak, Borneo.

Prof. T. G. Bonney, F.R.S., exhibited diamonds in eclogite. Boulders of eclogite, &c., occur in the "Blue Ground" at the Newlands Diamond Mines, West Griqua Land. Two of these contain diamonds. Thus the diamond cannot have its genesis in the "Blue Ground," nor can the latter, containing true boulders, be an igneous rock.

Mr. Walter Gardiner, F.R.S., and Mr. A. W. Hill showed histological preparations of plant tissues demonstrating the "connecting threads" which traverse the cell walls and establish a means of communication between the several cells.

Dr. F. W. Oliver exhibited a collection of Cingalese Podostemaceæ. The specimens included the majority of the Cingalese representatives of this remarkable family of flowering plants.

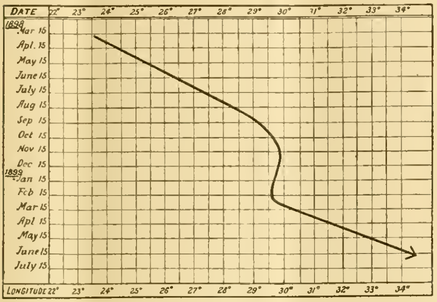
## THE RED SPOT ON JUPITER.

I HAVE frequently observed this object during the present apparition of the planet, but always found it exceedingly faint and only visible under good definition. Its aspect is that of a faint dusky stain attached to the northern side of the south temperate belt, and partially filling up the hollow formed in the great southern equatorial belt. With my 10-inch reflector—power 312—the following estimated times of transit were obtained, and I have added the corresponding longitude of the object:—

| Date. | Transit time. h. m. | Long. ° |
|---|---|---|
| 1898 November 29 | 19 55 | 31·9 |
| 1899 February 2 | 18 39 | 29·5 |
| 7 | 17 46 | 29·0 |
| 24 | 16 49 | 30·0 |
| 26 | 18 27 | 29·9 |
| April 19 | 11 20 | 32·0 |
| 26 | 12 3 | 30·8 |
| May 6 | 10 19 | 31·7 |
| 8 | 11 58 | 32·3 |
| June 4 | 9 18 | 34·4 |
| 6 | 10 57 | 34·8 |
| 9 | 8 26 | 34·4 |
| 11 | 10 4 | 34·0 |
| 14 | 7 32 | 32·9 |
| 16 | 9 13 | 34·4 |
| 21 | 8 20 | 33·5 |
| 23 | 9 58 | 33·1 |
| 26 | 7 29 | 33·7 |

This feature has shown a remarkable variation of motion during the last twelve months. In the winter there was a very decided acceleration of speed, but during the past three months the motion has been again retarded. The acceleration was first noticed here on the morning of February 3, when the marking came to the central meridian seven or eight minutes before its computed time. In the first half of 1898, and again during the last few months, the rotation period of the spot was nearly 9h. 55m. 42s., but for several months in the past winter the rate corresponded very nearly with 9h. 55m. 40·6s., the period employed by Mr. Crommelin in System II. of his ephemerides (*Monthly Notices*, November 1898). But, unfortunately, the precise character of the recent irregularity of motion cannot be determined, Jupiter having been too near the sun for effective observation during several months (August to November 1898).

The following diagram will, however, represent approximately the variation, which amounted to nearly one and a half seconds in the rotation period :—




My observation of 1898 November 29 was probably not very accurate, as the planet was low and very faint in the fog which prevailed. It is, however, in part confirmed by an observation obtained by Prof. G. W. Hough in 1898 December 10, who found the spot in the computed position, and saw no indication of the accelerated rate, which soon afterwards began to operate. In preparing the diagram I have, however, preferred to think that my autumn observation was a little late, as this requires a less sudden and extreme variation in the motion of the spot. This object should be carefully watched until the close of the present opposition, and the times of its transit secured on all possible occasions. There will be little difficulty in continuing observations until the end of August. If the red spot itself is not sufficiently distinct to be well observed when presented on the central meridian, transits of the middle of the hollow or bay in the southern side of the south equatorial belt will answer the purpose equally well.

Since the spot became a very prominent feature in 1878 it has exhibited an increasing rate of rotation, the period rising from 9h. 55m. 37s. to 9h. 55m. 42s. This increase has not been perfectly regular, for the motion has shown many irregularities similar to that which affected it during the past winter. No doubt the time will come when the maximum rate will be reached, to be followed thereafter by a marked shortening of the period. This appears to have been the case in 1859, and there is indication that the cycle of variations extends over a period of about 48½ years ; if so, we cannot expect a decided acceleration in the mean rate of the spot until the year 1907 or 1908.

There is every prospect that in a few years we shall be much better acquainted with the surface phenomena of Jupiter, and the variations affecting them, than we are at the present time. A very large number of useful observations were obtained in 1898, and many more are being secured during the present year. Observers are now generally recognising the necessity of accumulating observations of all the visible details of the surface, and determining the velocities of the various and varying currents in which they are situated.

The planet has recently afforded a singularly abundant display of spots and irregularities. Dark and white masses of material are thickly arranged near the equator, and from a partial investigation these appear to be moving rather slower than in 1898, the rate being now 9h. 50m. 25s., as against 9h. 50m. 23½s. during the previous opposition. A considerable number of white and dark spots are also distributed along the northern edge of the northern equatorial belt, which give a period slightly less than that of the red spot, but some of these markings are moving much more rapidly than others. The quickest of all is a small dark spot now in long. 145°, which has given a period of 9h. 55m. 15s., or about 27 seconds less than that of the red spot. In other latitudes a vast amount of detail is exhibited, and it is fortunate that the planet is being so sedulously studied by Mr. A. S. Williams, Prof. Hough, Mr. Gledhill, the Rev. T. E. R. Phillips, Captain Molesworth, and other able observers.

W. F. DENNING.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The Harkness Studentship in Geology has been awarded to Mr. A. L. Hall, Caius, first class in Natural Science Tripos, Part II., 1899.

The following College awards in Natural Science are announced :—

Clare : Scholarships to Cassidy, Goodchild, and F. G. Smith ; Exhibition to H. B. Jackson.

Trinity Hall : Scholarship to H. S. Newbould.

King's : Scholarship to Barger ; Exhibitions to Kewley, Mollison, Matthews, and Cartwright.

Emmanuel : Exhibitions to Walker, Heaton, Nixon, Sutton, Austin.

Mr. G. T. Bennett (Senior Wrangler 1890) has been elected a Senior Fellow, and Mr. H. S. Carslaw (Fourth Wrangler 1894) a Junior Fellow, at Emmanuel College.

At the beginning of the Michaelmas term, the General Board will proceed to elect a University Lecturer in Physical Anthropology for five years, with a stipend of 50*l.* a year. Names must be sent in to the Vice-Chancellor by September 30.

At Caius College, E. P. Widdicombe (Downing) and H. E. Wimperis have been elected to Salomons Engineering Scholarships, and R. H. Yapp (St. John's) to a Frank Smart Studentship for Botany.

At Christ's College, Scholarships for Natural Science have been awarded or continued to Hocking, Howlett, Brown, Gottschalk, Leake, Hoffmann, Fox, Muff, and Cumberlidge.

At Sidney Sussex College, Science Scholarships have been awarded to Bullough, Coales, Colt, Fearnsides, Fyson, and Stenhouse.

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SIR W. T. THISELTON-DYER, K.C.M.G., F.R.S., has been elected to an honorary studentship at Christ Church, Oxford.

DR. MAGNUS MACLEAN has been elected Professor of Electrical Engineering in the Glasgow and West of Scotland Technical College.

PROF. FRED W. MCNAIR has been elected president of the Michigan College of Mines. Prof. McNair has been for some years in charge of the department of mathematics and physics.

PROF. A. R. FORSYTH, F.R.S., Sadlerian professor of pure mathematics in the University of Cambridge, has had the honorary degree of LL.D. conferred upon him by the University of Dublin.

THE London School of Economics and Political Science, 10 Adelphi Terrace, W.C., offers the following research studentships, which will be awarded on examination in July : (1) One of 100*l.* a year, for two years, presented by the Hon. Bertrand Russell, Fellow of Trinity College, Cambridge. (2) One of 50*l.* a year, for two years. (3) The "Lucy Rose" studentship of 50*l.* a year, for two years, presented by Mr. Edward Rose—open to women students only. Preference will be given to a woman student sprung from the working classes. The studentships are intended to enable students to become trained investigators, and to promote the execution of definite pieces of original work relating either to past or present economic or political conditions.

THE *Times* states that the Association of Directors and Organising Secretaries for Technical and Secondary Education have addressed a memorial to the Government with regard to the alteration made in the Board of Education Bill in the Standing Committee of the House of Lords at the instance of Lord Spencer. The association entreat the Government to induce the House of Commons to restore Clause 3 (1) to its original shape, on the ground that the term "school supplying secondary education" (used in that clause) is a very wide one, and, if interpreted in the light of the report of the Royal Commission on Secondary Education, must include polytechnics, higher grade schools, science schools, art schools, commercial schools, and agricultural schools. These, it is submitted, are the very types of schools which are being founded or developed all over the kingdom by the county councils, which supply the pressing industrial needs of the day, and demand that guidance and encouragement which it is the object of the Bill to supply.

THE second reading of the Board of Education Bill was agreed to by the House of Commons on Monday. Sir John Gorst, in moving the second reading, explained that the object of the Bill is to enable the Government to create a department

of State which may have conferred upon it powers in relation to secondary education. The Royal Commission on Secondary Education recommended that there should be a central authority, a Government Department, in London, to supervise secondary education and local authorities in the country. The opinion of the Government is that the central authority in London must be created and arranged before the local authorities in the country can be usefully set on foot, and it is to organise and arrange a central department in London to exercise the sort of functions recommended by the Royal Commission that this Bill has been brought before Parliament. The Bill proposes the abolition of the existing Committee of Council on Education and to replace it by a Board of Education consisting of the First Lord of the Treasury, the Chancellor of the Exchequer, and the Secretaries of State for various departments, having a President and a Parliamentary Secretary in the same manner as the Local Government Board and the Board of Trade. To this new Board of Education are to be transferred all the powers and functions which are at present exercised by the Committee of Council, so that it will stand in relation to educational matters and the distribution of the science and art grants and technical instruction exactly in the same position, and have exactly the same powers, as the present Education Department possesses.

## *SCIENTIFIC SERIALS.*

*American Journal of Science*, June.—Othniel Charles Marsh—portrait and obituary notice.—The Camden Chert of Tennessee and its Lower Oriskany Fauna, by J. M. Safford and C. Schuchert. The latter describes in detail a peculiar chert formation discovered by the former.—Recent discovery of rocks of the age of the Trenton formation at Akpabok Island, Ungava, by J. F. Whiteaves. Describes the fossils collected by Dr. R. Bell, of the Canadian Geological Survey, on Akpabok Island, between Ashe Inlet and Fort Chimo, and concludes that they belong to a lower geological horizon than the Hudson River formation as at first supposed.—Studies in the Cyperaceæ, No 10, by T. Holm. Describes the North American species of *Fimbristylis*, Vahl.—On Roscœlite, by W. F. Hillebrand and H W. Turner. Roscœlite is a vanadium mica, some specimens of which show a tendency to crystallise in little rosettes. It occurs most frequently embedded in quartz at Placerville, California. It contains 45 per cent. $SiO_2$, 24 per cent. $V_2O_3$, 11 per cent. alumina, 10 per cent. potash, 4 per cent. water, and traces of magnesia and ferrous oxide.—Gravitation in gaseous nebulæ, by F. E. Nipher. If R be the radius of a spherical mass of gas of cosmical dimensions, and T its temperature, the product TR is constant. The heat capacity of such a gravitating mass is negative. If heat leaves the gas, it contracts and becomes warmer. The physical condition to be satisfied in order that a central mass or core, having a radius equal to that of the sun, should contain a mass equal to that of the sun, is that its temperature is 20 million degrees Centigrade. The pressure at the surface of this sphere is 366 million atmospheres. The average density of the spherical mass, which is three times the density at the surface of the hydrogen sun, is about 7 per cent. less than the average density of the sun itself, but the nature of the gas is immaterial. In the sun as it is, the rarefied external parts of the solar nebula have parted with their heat, and the temperature throughout the mass has ceased to be uniform. But the abolition of cosmical pressure has almost wholly compensated the fall in temperature of the sun from 20 millions at least to perhaps 10,000 degrees.

*Symons's Monthly Meteorological Magazine*, June.—Unprecedented frost in the United States in February 1899. In that month 64°·8 were recorded at Camden Town, being 2°·3 higher than any reading recorded in February in London during 104 previous years, while about the same time at New Orleans an equally unprecedented low reading of 7° (25° below freezing) was registered. Prof. Garriott, in charge of the forecast division, states that the most remarkable series of cold waves in the history of the Weather Bureau traversed the United States from the North Pacific to the South Atlantic coasts during the first half of February, damaging crops and fruit in the southern States to the extent of millions of dollars. The cause of this intense cold is ascribed to barometric depressions in the south, combined with a large area of high barometer over British north-west territory.—On a recent recurrence in weather: a lunar or 30-day period, by H. H. Clayton. The author has treated the temperatures observed at the Blue Hill Meteorological Observatory, from July 1898 to February 1899, in the same way as Mr. A. MacDowall has treated the temperatures for the same time observed at Greenwich. The figures show a well-marked period of about thirty days, but the interval is too short to determine whether the period had the exact length of the lunar period, or had any relation of cause and effect.

*Wiedemann's Annalen der Physik und Chemie*, No. 5.—A double trough refractometer, by W. Hallwachs. The author describes certain improvements in his differential interference refractometer for liquids, and measurements made with it on solutions of cadmium bromide, sugar, chloracetic acid, and chloracetates.—Optical properties of burnt-in gold and platinum films, by G. Breithaupt. Thin layers of gold, platinum, and other metals were burnt into glass or obsidian, and tested with regard to their dispersion. Gold showed normal dispersion, so did brass, when well polished with cotton wool. Platinum, steel, and nickel steel showed anomalous dispersion.—A new method of detecting electric waves, by A. Neugschwender. This is the author's second communication on the subject of his damp anti-coherer. He found that the establishment of conductivity between the two sides of a metallic slit on moistening it depended upon the presence of some metallic salt in the moisture which could be separated electrolytically. Under the microscope the metal so separated out forms a tree-like formation, which suddenly breaks up on the impact of electric waves, thus destroying the conductivity.—Determination of the pitches of Appunn's pipes by optical and by acoustic means, by F. A. Schulze. The author has repeated Appunn's determinations of the pitches of high pipes by the method of revolving mirrors, by Kundt's dust figures, and by Quincke's interference tube. He confirms Stumpf's result that the highest Appunn pipes have pitches assigned to them which are wrong by several octaves.—Determination of high pitches by difference tones, by C. Stumpf. The author defends the trustworthiness of the method of difference tones against Appunn's criticism.—On the refracted wave at so-called total reflection, by W. Voigt. Against Ketteler's criticism the author maintains that there exists a stream of energy parallel to the surface of the second medium in "total" reflection, and that this stream of energy is nothing else than a ray of light.—Thermal insulators, by W. Hempel. This is a comparison of the insulating properties of Dewar tubes silvered on the outer surface of the inner tube, with those of wool and feathers. Eiderdown turns out to be the most effective of the old insulators, as it is capable of maintaining a charge of solid carbonic acid and ether below −66° for an hour and a half, whereas the same charge surrounded by cotton or silk reaches −56° in the same time, and −33° when surrounded by an imperfect vacuum. At the same time, the charge remains below −70° in a Dewar tube, the initial temperature in every case being −79°.

## *SOCIETIES AND ACADEMIES.*

### LONDON.

**Royal Society**, May 18.—"Diffusion of Ions into Gases." By John S Townsend, M.A. (Dublin), Clerk Maxwell Student, Cavendish Laboratory, Cambridge. Communicated by Prof. J. J. Thomson, F.R.S.

In the paper upon this subject the principles of the theory of interdiffusion of gases are applied to the diffusion of ions produced in a gas by the action of Röntgen rays. When a gas is ionised in this way, and then removed from the action of the rays, the conductivity gradually disappears. If there are no electric forces acting on the gas, the loss of conductivity is due partly to the encounters between positive and negative ions, and partly the effect of the surface of the vessel which discharges those ions that come into contact with it.

The ions may be considered as a separate gas (A) mixed with the ordinary uncharged molecules (B), which are unaffected by the rays. When the mixture is passed along a metal tube there is a loss of conductivity, due to the ions coming into contact with the surface. A formula is given for calculating the rate of diffusion of the ions A into the gas B from this loss of conductivity, which was found experimentally. The following values were obtained for the coefficients of diffusion of ions into air, oxygen, carbonic acid, and hydrogen.

It was found that the rates of diffusion of the positive and negative ions differed more when the gas was dry than when it was moist.

*Values of $\kappa$ in Square Centimetres per Second.*

| Gas | $\kappa$ for + ions in dry gas | $\kappa$ for − ions in dry gas | $\kappa$ for + ions in moist gas | $\kappa$ for − ions in moist gas |
|---|---|---|---|---|
| Air ... ... | ·0274 | ·042 | ·032 | ·035 |
| Oxygen ... | ·025 | ·0396 | ·0298 | ·0358 |
| Carbonic acid... | ·023 | ·026 | ·0245 | ·0255 |
| Hydrogen ... | ·123 | ·190 | ·128 | ·142 |

From the equation of motion

$$\frac{1}{\kappa} pu = -\frac{dp}{dx} + nXe$$

(where $p$ is the partial pressure of the ions, $n$ the number of ions per c.c., $e$ the charge on each ion, X the electric force at any point, and $u$ the velocity of the ion in the $x$ direction), it can be seen that when $\frac{dp}{dx} = 0$ the velocity $u$, due to the electric force X, is $\frac{nXe\kappa}{p}$.

If the potential gradient is one volt per centimetre, $X = \frac{1}{300}$ in electrostatic units, and the corresponding value of $u$ is $u_1 = \frac{\kappa e}{300} \cdot \frac{n}{p}$.

Let N be the number of molecules per c.c. in a gas at pressure P, equal to the atmospheric pressure and temperature 15° C., the temperature at which $u_1$ and $\kappa$ were determined.

The quotient $\frac{N}{P}$ may be substituted for $\frac{n}{p}$ in the above equation, and N$e$ is therefore obtained in terms of qualities which can be determined experimentally.

$$Ne = \frac{3 \; 10^8 u_1}{\kappa}, \text{ since } P = 10^6 \text{ in C.G.S. units.}$$

Substituting for $u_1$ the mean velocities given by Prof. Rutherford (E. Rutherford, *Phil. Mag.*, November 1897), and for $\kappa$ the mean coefficient of diffusion obtained for the dry gases, and the following values of N$e$ are obtained :—

| | |
|---|---|
| Air ... ... ... ... | $Ne_A = 1{\cdot}35 \; 10^{10}$ |
| Oxygen ... ... ... ... | $Ne_O = 1{\cdot}25 \; 10^{10}$ |
| Carbonic acid ... ... ... | $Ne_e = 1{\cdot}30 \; 10^{10}$ |
| Hydrogen ... ... ... | $Ne_H = 1{\cdot}00 \; 10^{10}$ |

Experiments on electrolysis show that one electrodynamic unit of electricity in passing through an electrolyte gives off 1·23 c.c. of hydrogen at temperature 15° C. and pressure $10^6$ C.G.S. units. The number of atoms in this volume is 2·46 N, so that if E is the charge on an atom of hydrogen in the liquid electrolyte

$$2{\cdot}46 \; NE = 1 \text{ electrodynamic unit of quantity}$$
$$= 3 \; 10^{10} \text{ electrostatic units.}$$

Hence $NE = 1{\cdot}22 \; 10^{10}$, the charge E being expressed in electrostatic units. Since N is constant, these numbers show that the charges on the ions produced by Röntgen rays in air, oxygen, carbonic acid, and hydrogen are all the same, and equal to the charge on an atom of hydrogen in a liquid electrolyte.

Prof. J. J. Thomson (J. J. Thomson, *Phil. Mag.*, December 1898) has shown that the charge on the ions in oxygen and hydrogen, which have been made conductors by Röntgen rays, is $6 \; 10^{-10}$ electrostatic units, and is the same for both gases.

Taking this value for the charge $e$, the number of molecules in a cubic centimetre of a gas is obtained :

$$N = 2 \; 10^{19}.$$

The weight of a molecule of hydrogen $\frac{\rho}{N}$ is therefore

$$4{\cdot}5 \; 10^{-24} \text{ grammes.}$$

In order to prove that the positive and negative ions have the same charge, the ratio of the coefficients of diffusion must be shown to be equal to the ratio of the velocities. This subject has been investigated by Prof. Zeleny (J. Zeleny, *Phil. Mag.*, 1898), and it was found that the negative ion travels faster than the positive ion in air, oxygen and hydrogen, the ratio of the velocities being 1·24 for air and oxygen, 1·15 for hydrogen, and 1·0 for carbonic acid.

Royal Society, June 15.—"On the Orientation of Greek Temples, being the Results of some Observations taken in Greece and Sicily in the month of May 1898." By F. C. Penrose, M.A., F.R.S.

The orientation of the Cabeirion Temple, near Thebes, on which the angle has been disputed (see p. 46 in my paper of 1897), was remeasured with the theodolite in May 1898, and the previous observations confirmed. An additional example is added from an archaic Temple of Neptune in the Isle of Poros, introducing the employment of the bright zodiacal star Regulus, which I had not before met with.

In Sicily the re-examination of the temples at Girgenti, where, in my former visit, I had relied for azimuth on the sun's shadow and the time, has enabled me to give to the elements some amendments in detail, the only point of consequence being that the orientation date of the temple named Juno Lacinia is brought within the period of the Hellenic colonisation of that city.

The most interesting point in the paper seems to be, that in the case of two Athenian temples, namely, the Theseum and the later Erechtheum—*i.e.* the temple now partially standing—it is shown that the days of those months on which the sunrise, heralded by the star, illuminated the sanctuary coincided exactly, on certain years of the Metonic cycle, with the days of the Athenian lunar months on which three important festivals known to be connected with at least one of those temples were held. The years so determined agree remarkably well with the probable dates of the dedication of those temples; and in the case of the first mentioned, the festival, which was named The Thesea, seems to leave little doubt that the traditional name of the temple, which has recently been much disputed, is the correct one.

"Collimator Magnets and the Determination of the Earth's Horizontal Magnetic Force." By C. Chree, Sc.D., LL.D., F.R.S., Superintendent of the Kew Observatory. Communicated by the Kew Observatory Committee of the Royal Society.

During the last forty years, there have been examined at Kew Observatory upwards of 100 collimator magnets used in observing the horizontal force and declination.

The "constants" of these magnets—temperature and induction coefficients, and moment of inertia—have been determined at the Observatory, and the tables based on these determinations have served to reduce magnetic observations at a large number of the leading magnetic observatories.

The present paper deals with the data recorded in the Observatory books for the constants specified above, and with other quantities—such as the "permanent" magnetic moment—which are deducible from the records. It determines the mean values of the several quantities for the instruments of the leading English makers, and investigates whether relations do or do not exist between them. It then deduces from the records the probable errors in the values of the several quantities, proceeding on the hypothesis that the methods of determining them are correct. It next examines, from a mathematical standpoint, the accuracy of the formulæ employed in reducing horizontal force observations, and, from a physical standpoint, the possibility of differences between the quantities determined at the Observatory and the quantities actually concerned in horizontal force observations.

The various sources of uncertainty are dealt with, and an attempt is made to ascertain to what extent they may affect the values found for the horizontal force.

The results of the paper are of too technical a character to admit of their being summarised briefly in an intelligible way.

Physical Society, June 23.—Mr. T. H. Blakesley, Vice-President, in the chair.—A paper on the magnetic hysteresis of cobalt, by Prof. Fleming, Mr. A. W. Ashton, and Mr. H. G. Tomlinson, was read by Mr. Ashton. A rectangular sectioned circular ring of cobalt was insulated with silk tape and wound over with four secondary coils put on at quadrantal positions. Over these secondary coils six primary coils were placed, and the ring was submitted to a complete set of magnetic tests with a ballistic galvanometer. From these observations various

curves have been plotted, and the results have been compared with a similar set of readings taken on a cast iron ring. A chemical analysis of the cobalt showed that it contained about 1 per cent. of iron and 1 per cent. of nickel. The authors conclude that, although in general form the magnetisation curve for cobalt resembles that of cast iron, its hysteresis exponent is similar to that of annealed soft iron. The absolute hysteresis values corresponding to various maximum flux densities are, however, not very different from those of a typical variety of cast iron. Prof. Everett referred to the fact that the sample of cobalt contained about 1 per cent. of iron, and said that it would be interesting to know how cobalt free from iron would behave. The Chairman said that the hysteresis curves obtained from the step by step method could not be applied to dynamos, because the time taken to perform the cycle altered the shape of the curve. He would like to see the curves for cobalt determined in cases where the cycles were quickly executed.—A discussion on physical tables was commenced by Mr. J. Lupton. Mr. Lupton briefly reviewed some of the difficulties met with in compiling physical tables and in keeping them up to date. He divided them into four classes according to their objects, and criticised several well-known books of constants. He pointed out the danger of leaving out apparently obvious figures, and referred to the necessity for accurate proof reading. Prof. Everett said that in his work he had aimed at giving an idea of the meanings of various numbers, rather than stating them with great accuracy. He drew attention to the difficulty of condensing large series of numbers into a clear and concise table. Mr. Watson said that it was important that the units in which numbers were expressed should be stated at the head of each table. The Chairman having pointed out one or two small points to be attended to in the compilation of tables, the Society adjourned until next October.

**Chemical Society**, June 15.—Prof. T. E. Thorpe, President, in the chair.—The following papers were read:—On the decomposition of chlorates, with special reference to the evolution of chlorine and oxygen, by W. H. Sodeau. The author concludes that on heating barium chlorate, two reactions proceed simultaneously; (*a*) an exothermic decomposition into chloride and oxygen, and (*b*) an endothermic decomposition into oxide, chlorine and oxygen.—Action of hydrogen peroxide on formaldehyde, by A. Harden. Hydrogen peroxide and formaldehyde react in presence of much soda in accordance with the following equation:

$$H_2O_2 + 2CH_2O + 2NaHO = 2HCO_2Na + H_2 + 2H_2O.$$

With excess of formaldehyde reaction proceeds rapidly, whilst in presence of excess of hydrogen peroxide it proceeds slowly and incompletely. The behaviour of other oxides towards formaldehyde and soda has also been investigated.—Homocamphoronic and camphononic acids, by A. Lapworth and E. M. Chapman. α-Dibromocamphor is rapidly oxidised by nitric acid in presence of silver nitrate, with formation of small quantities of a nitro-compound, $C_{10}H_{14}N_2O_6$, and a tribasic acid, $C_{10}H_{16}O_6$, named homocamphoronic acid; the latter yields on heating first an anhydro-acid, and then a ketonic acid, $C_9H_{14}O_3$, termed camphononic acid.—Action of silver compounds on α-dibromocamphor, by A. Lapworth.—The colouring matter of cotton flowers, by A. G. Perkin. The flowers of the cotton plant, *Gossypium herbaceum*, contain a glucoside, gossypetin, $C_{16}H_{12}O_8$; it is a colouring matter, yields a hexacetyl-derivative, and resembles thujetin.—Experiments on the synthesis of camphoric acid, by H. A. Auden, W. H. Perkin, jun, and J. L. Rose. Ethyl isoamylacetoacetate was converted into ethyl α-isoamyl-ββ-hydroxycyanobutyrate, which on hydrolysis yielded methylhydroxyisoamylsuccinimide; the latter on further hydrolysis yielded the corresponding acid

$$COOH.CMe(OH).CH(C_5H_{11})COOH,$$

from which it was hoped by elimination of water to synthesise camphoric acid. The attempt was not successful.—Methylisoamylsuccinic acid, i., by W. T. Lawrence.—Condensations of anhydracetonebenzil and its analogues with aldehydes, by F. R. Japp and A. Findlay.—Triphenyloxazolone, by F. R. Japp and A. Findlay.—Interaction of phenanthraquinone, acetophenone, and ammonia, by F. R. Japp and A. N. Meldrum.—Furfuran derivatives from benzoin and phenols, by F. R. Japp and A. N. Meldrum.—Interaction of benzoin with phenylenediamines, by F. R. Japp and A. N. Meldrum.—The condensation of ethyl salts of acids of the acetylene series with ketonic compounds, by S. Ruhemann and A. V. Cunnington.—Dextro-ac-tetrahydro-β-naphthylamine, by W. J. Pope. Inactive ac-tetrahydro-β-naphthylamine may be resolved into its optically active components by means of its dextro-α-bromocamphorsulphonate; the pure dextro-compound was thus prepared.—The resolution of racemic tetrahydroparatoluquinaldine into its optically active components, by W. J. Pope and E. M. Rich. Inactive tetrahydroparatoluquinaldine may be resolved into its optically active components by crystallisation with dextro-α-bromocamphorsulphonic acid. — Isomeric salts of hydrindamine containing pentavalent nitrogen, by F. S. Kipping. The author has endeavoured to resolve α-hydrindamine into its optically active components by Pope and Peachey's method with bromocamphorsulphonic acid and by crystallisation with cis-π-camphanic acid; two salts are formed in each case, but the regenerated base is optically inactive.—Synthesis of phenoketoheptamethylene, by F. S. Kipping and Miss L. Hall.—Organic compounds containing silicon, by F. S. Kipping and L. L. Lloyd. The authors have prepared triphenylsilicol, $(C_6H_5)_3$ Si.OH, its acetyl derivative, $(C_6H_5)_3$ Si.OAc, and the corresponding ether, $(C_6H_5)_3Si.O.Si(C_6H_5)_3$.—The velocity of reaction before complete equilibrium, by M. Wilderman.—The ultra-violet absorption spectra of albuminoids in relation to that of tyrosin, by A. W. Blyth.—An explanation of the laws which govern substitution in the case of benzenoid compounds (third notice), by H. E. Armstrong. The author advocates the view that in compounds which ordinarily furnish meta-di-derivatives, the radicle ($NO_2$, $CO_2H$, &c.) is not only unattractive and possessed of little or no ortho-para-orienting power, but even exercises an inhibiting influence on these positions.—The colouring matters of dyer's broom and heather, by A. G. Perkin and F. G. Newbury.

**Linnean Society**, June 15.—Dr. A. Günther, F.R.S., President, in the chair.—The President exhibited a living specimen of a tree-frog (*Polypedates quadrilineatus*) which was introduced accidentally into Kew Gardens with a consignment of plants from Singapore. This is not the first instance of accidental introduction of a tropical frog into the Royal Gardens, Kew. Some five years ago a species of *Hylodes*, from Dominica, appeared in some numbers in several of the propagating-houses, and has evidently reproduced its species since arrival.—Mr. W. Whitwell exhibited: (1) The only known British specimen of *Botrychium matricariaefolium*, A. Braun, gathered in July 1887 on the seashore at Stevenston, Ayrshire (*Journ. Bot.*, 1898, pp. 291–297). (2) An undescribed variety of *Asplenium Ruta-muraria*, Linn., from an old wall on Dartmoor, about five miles from Plympton. (3) A specimen of rye with two ears on the same stalk, gathered at Romsey, Hants.—Mr. Robert T. Günther read a paper on the natural history of Lake Urmi in N.W. Persia, the neighbourhood of which he had explored during the autumn of last year. The collections which he had made there had been worked out by a number of specialists, each of whom had furnished a report on the specimens submitted to him. In many of the groups (notably amongst the fishes) several new species were described; and a good deal of interest centred in the skull and horns of a wild sheep which had been picked up on Koyun Daghi, the largest island in Lake Urmi. Although no living wild sheep were observed there during the traveller's short visit, small herds were reported to exist, the island, with lofty and precipitous hills, being apparently well adapted to their requirements. The head in question, that of an adult ram, unlike the typical *Ovis orientalis* found in Northern Persia and Armenia, more nearly approached that of *Ovis ophion*, the mufflon of Cyprus, a curious and unexpected resemblance.—Dr. A. B. Rendle read a paper entitled "A systematic revision of the genus *Najas*," a primitive genus of Monocotyledons containing about thirty known species, generally distributed in both Old and New Worlds, and consisting of submerged herbs, often of great delicacy, growing in mud in fresh or brackish water.

**Royal Meteorological Society**, June 21.—Mr. F. C. Bayard, President, in the chair.—Dr. R. H. Scott, F.R.S., read a paper on the heavy falls of rain recorded at the seven observatories connected with the Meteorological Office during the twenty-eight years 1871–98. The data has been derived from the records of the Beckley self-recording rain gauges at the following places:—Valencia, Armagh, Glasgow, Aberdeen, Falmouth, Stonyhurst, and Kew. These records have been tabulated for each hour, and it is from these hourly tabulations

that Dr. Scott has extracted the heavy falls. He finds that Falmouth has the greatest frequency of heavy falls, the next station being Valencia, and then Stonyhurst. The most exceptional fall during the whole period was at Glasgow at five p.m. on August 11, 1895, when as much as 0·80 in. was collected in ten minutes. The information given in this paper is likely to be of much service to engineers who want to know the rate at which rain sometimes falls in short periods.—A paper by Mr. J. Baxendell, describing his new self-recording anemoscope, was read by the Secretary. This instrument, which records the direction of the wind on an open scale, has been in use at Southport for more than a year, and works very satisfactorily. The vane, which is an exceedingly light, but large double-bladed, one, is sensitive even in light airs, and is steady in the strongest gales. The records from this anemoscope, which were exhibited at the meeting, were very clear and of an interesting character, and showed the instrument to be a valuable companion to the Dines pressure tube anemometer.—A paper, by Mr. R. C. Mossman, on the average height of the barometer in London, was also read by the Secretary. Some years ago Mr. H. S. Eaton worked out the mean monthly and annual height of the barometer in London for one hundred years. Mr. Mossman has carried on this discussion for a further period of twenty years; but he finds that the results for the one hundred and twenty years are practically identical with those for one hundred years.

**Zoological Society**, June 20.—Dr. Albert Günther, F.R.S., Vice-President, in the chair.—Mr. W. E. de Winton made some remarks on a small collection of mammal-skins from British Central Africa, which had been transmitted to Mr. Sclater by Mr. Alfred Sharpe, C.B. Mr. de Winton also exhibited the mounted heads of a male and female red-flanked Duiker (*Cephalophus rufilatus*, Gray), collected by Mr. J. F. Abadie in the Borgu country of the Niger district; and the skull of a male of the same species obtained by Captain W. Giffard near Gambaga, in the back country of the Gold Coast.—The Hon. Walter Rothschild read a memoir on the cassowaries, which contained notes on and an enumeration of the species and geographical races of these birds.—Mr. C. W. Andrews gave a description of a new type of bird, the skull and pelvis of which had lately been discovered by Mr. W. H. Shrubsole, enclosed in a nodule in the London clay of Sheppey.—A communication from Mr. J. Y. Johnson treated of the antipatharian corals of Madeira, and of a specimen from the West Indies in the British Museum.—A communication was read from Mr. Stanley S. Flower, containing notes on the Proboscis monkey (*Nasalis larvatus*) made on a young male example of this animal which had lived for a short time in the Egyptian Zoological Gardens at Ghizeh, Cairo.—A communication from Mr. Alexander Sutherland on the temperature of the Ratite birds was based on observations made on specimens of birds of this family in the Society's Gardens.—Mr. G. A. Boulenger, F.R.S., read a paper on the American Spade-foot (*Scaphiopus solitarius*, Holbrook), in which he pointed out that this frog had affinities with both *Pelobates* and *Pelodytes*, and that these three genera together formed one natural family, viz. the *Pelobatidae*.—Mr. W. L. H. Duckworth read a paper containing an account of the female chimpanzee, known as "Johanna," living in the menagerie of Messrs. Barnum and Bailey. The history and habits, diet in captivity, intellectual attainments, physical proportions, and appearance of this ape were dealt with in the paper, as also was the question of species, the author regarding the specimen as allied to the chimpanzees rather than to the gorilla.—A communication from Mr. R. Lydekker gave an account of a new species of Kob antelope (specimens of which had recently been received in a collection from Sierra Leone), under the name of *Cobus nigricans*. Mr. Lydekker also drew attention to skins of a Kob from Barotseland, recently received at the British Museum, which he had identified with *C. senganus*. The specimens of the latter form he stated differed so slightly from the type of *C. vardoni* that he was inclined to regard them as not worthy of specific rank, and to refer them to a subspecies which he proposed to call *C. vardoni senganus*.—Mr. Lydekker also sent a description of a specimen of a leopard from the Caucasus, belonging to the collection of Prince Demidoff, which differed in several respects from the common leopard, and which he proposed to regard as a subspecies under the name of *Felis pardus tulliana*.—A third communication from Mr. R. Lydekker related to the former existence of a Sirenian of some kind in St. Helena, which had been noticed by former observers in that island, but to which no reference had been made by recent authors.—Mr. F. E. Beddard, F.R.S., read a paper on the brain of the Capybara (*Hydrochoerus capybara*) based on examination of specimens in the Society's Gardens.—Mr. Beddard also read a paper, prepared by himself and Miss Sophie M. Fedarb, containing notes on the anatomy of the worms *Perichaeta biserialis* and its variations and *Trichochaeta hesperidum*.—Dr. Woods Hutchinson read a paper on the zoological distribution of tuberculosis from observations made mainly in the Society's Gardens. Of 215 autopsies made in the prosector's room during the past six months, 49 presented the lesions of tuberculosis, *i.e.* 25·3 per cent. of the mammals and birds. This mortality fell most heavily upon the ruminants and gallinæ, and least so upon the carnivores and raptors. Race or family appeared to exert little influence upon susceptibility, mode of housing only a small amount, and food and food-habits much more. A close correspondence appeared to exist between immunity and the relative size of the heart in both birds and mammals.—A communication was read from Dr. A. G. Butler containing an account of a small collection—consisting of nineteen specimens—of butterflies sent home from Muscat by Lieut.-Colonel A. S. G. Jayakar.—Dr. J. W. Gregory read a paper containing an account of the West Indian species of corals of the genus *Madrepora*.—A communication was read from Marquis Ivrea on the black roedeer of Hanover.

### EDINBURGH.

**Mathematical Society**, June 9.—Dr. Morgan, President, in the chair.—The following papers were read:—Systems of circles analogous to Tucker circles, part iii.; systems of conics connected with the triangle; systems of spheres connected with the tetrahedron, Mr. Third; "La perspective d'une conique est une conique" (démonstration élémentaire), M. L. Leau.

### PARIS.

**Academy of Sciences**, June 19.—M. van Tieghem in the chair.—On a class of isothermic surfaces connected with the deformation of surfaces of the second degree, by M. Gaston Darboux. A further development of the subject dealt with in a previous note.—On the determination of the integrals of the equations to partial derived functions of the second order by their values on a closed curve, by M. Émile Picard.—Late watering of the vine, by M. A. Müntz. Towards the end of a dry season the growth of the grapes is impeded and small yields are obtained, although the wine produced is often of higher quality. Nevertheless, this increased value does not compensate for the diminished quantity, and artificial watering is therefore resorted to. The author has experimented on the effects of this practice, and finds that the grapes thus treated increase in weight to the extent of 25 to 30 per cent. as compared with the untreated fruit. Part of this increase is due to simple absorption of water, but not the whole, since there is a notable increase in the sugar and vegetable acids. It is noteworthy that delayed watering causes a retrogression in the ripening process, the relative proportions of the sugar and acids becoming what they were at an earlier part of the year.—Note on the toxicity of the urine of children, more especially in cases of appendicitis, by MM. Lannelongue and Gaillard. The toxicity of the urine of normal children is inferior to that of the urine of adults, but is largely increased in cases of acute appendicitis. The colour of the pathological fluid is also more marked, and the density and amount of extractives present are greater.—Electromotive force produced in a flame by magnetic action, by M. R. Blondlot. If two platinum wires are placed symmetrically at the opposite edges of an ordinary gas flame and connected with a capillary electrometer, only a feeble oscillatory movement of the mercury is noticed, but a steady deflection is produced when the flame is placed between the poles of an electromagnet. This phenomenon is doubtless due to electromagnetic induction, the effect of the heated gases constantly ascending in the magnetic field being the production of an electromotive force the direction of which is normal both to the lines of force and to the direction in which the gases are moving.—Influence of the manner of introduction on the therapeutic effects of antidiphtheritic serum, by M. S. Arloing. From the experiments described it appears that with the dog the therapeutic effect of the serum is more marked when it is introduced into the blood instead of into the connective tissue, whereas with the guinea-pig the reverse is the case.—Observations made at the Bordeaux

Observatory on the partial eclipse of the sun, June 7, by MM. Féraud, Doublet, Esclangon and Courty.—On some anomalous surfaces applicable to a plane, by M. H. Lebesgue. The author shows that developable surfaces are not the only surfaces which are applicable to a plane.—On the calculation of the integrals of differential equations by the method of Cauchy-Lipchitz, by M. Paul Painlevé.—Comparison of the velocities of propagation of electromagnetic waves in air and along wires, by M. C. Gutton. The two velocities in question have been compared by a more exact method than those hitherto employed, and their equality verified to within 1 in 200.—Electrolytic action observed in the neighbourhood of a Crookes' tube, by MM. H. Bordier and Salvador. When an electrolytic cell consisting of two plates of copper or zinc immersed in a solution of copper or zinc sulphate is connected with a delicate galvanometer and placed in proximity to a Crookes' tube in action, a notable polarisation of the electrodes of the cell is observed. The effect is not due to the action of the X-rays, but is caused by a secondary, dark discharge from the anode and kathode of the tube, which is equivalent to a current of high electromotive force but of feeble intensity.—On magnet steels, by M. F. Osmond. Experiments on the magnetic properties of steels containing varying amounts of manganese and of nickel.—Researches on the vapours emitted by the two varieties of mercuric iodide, by M. D. Gernez. Experiments are described which show that the vapour of mercuric iodide, whatever its origin, is capable of condensing to form, at the same temperature, either the red or the yellow crystals of the compound, according as either variety is employed as a starting point for crystallisation. The condition of the vapour is, in fact, analogous to that of melted sulphur, from which three forms of crystals may be obtained at will according to the form of the crystal introduced as a nucleus.—Remarks on the oxides of sodium and on the chemical function of water as compared with that of hydrogen sulphide, by M. De Forcrand. The author discusses the heats of formation of the oxides of sodium, as determined by himself and by other observers, and endeavours to show that the two hydrogen atoms in the molecule of water are distinctly different in function, whereas in hydrogen sulphide they are of equal value. Water is therefore to be considered as an unsymmetrical, hydrogen sulphide as a symmetrical, compound, as may be indicated by the formulæ H—OH and H—S—H respectively.—On the decomposition of carbonic oxide in the presence of metallic oxides, by M. O. Boudouard. The experiments described in previous communications have been extended to a temperature of 800° C.; the metallic oxides employed were those of cobalt, nickel, and iron. The decomposition is a function of the time, the amount of carbonic anhydride formed increasing in a regular manner until the limit, at 800°, of 7 per cent. is reached. The velocity of the reaction is much greater at 800° than at 650°.—On the decomposition of carbonic anhydride in the presence of carbon, by M. O. Boudouard. An extension of previous researches on this reaction. The limiting composition of the gaseous mixture at 800° is 93 per cent. of carbonic oxide and 7 per cent. of carbonic anhydride. At 925° there still remained 4 per cent. of carbonic anhydride.—On a lower homologue of citric acid, by M. Augustin Durand. By treating the sodium derivative of ethylic oxaloacetate with hydrocyanic acid and hydrolysing the cyanhydrin thus produced, the authors have obtained a new acid of the composition

$$COOH.CH_2.C(OH).(COOH)_2.$$

Experiments are in progress for the preparation of other homologues of citric acid.—On Morren's glands in European *Lumbricoides*, by M. Édouard de Ribaucourt. On the fall of leaves and the cicatrisation of the wound, by M. A. Tison.—The upper layers of the Jurassic soil in Bas-Boulonnais, by M. Munier-Chalmas.—Crystallisation of blood-albumin, by Mlle. S. Gruzewska. Abundant crystalline deposits of albumin were obtained from the blood of the guinea-pig by employing a low temperature and working with solutions almost saturated with ammonium sulphate.

NEW SOUTH WALES.

**Royal Society**, May 3.—The President, G. H. Knibbs, in the chair.—The following gentlemen were elected officers for the current year:—President, W. M. Hamlet; Vice-Presidents, Prof. Anderson Stuart, Charles Moore, Prof. T. W. E. David, Henry Deane; Hon. Treasurer, H. G. A. Wright; Hon. Secretaries, J. H. Maiden, G. H. Knibbs.—The theme of the anniversary addres delivered by the President, Mr. G. H. Knibbs, was the influence of science upon civilisation.

AMSTERDAM.

**Royal Academy of Sciences**, May 27.—Prof. H. G. van de Sande Bakhuyzen in the chair.—Prof. Kamerlingh Onnes presented, for publication in the *Proceedings*, a paper by Dr. L. H. Siertsema, entitled "Measurements of the magnetic rotation of the plane of polarisation in oxygen at various pressures." The magnetic rotation in oxygen was measured in the same way as was formerly done in the case of pressures of 97, 73, 49 and 38 atmospheres, and at these pressures it was found to be proportional to the density of the gas.—Prof. van Bemmelen presented, on behalf of Dr. F. A. H. Schreinemakers, for publication in the *Proceedings*, a paper entitled "On the system water, phenol, acetone."—Prof. Lobry de Bruyn communicated the results of the inquiries of Prof. Holleman, who has determined how, on the nitration of benzoic acid and its methyl and ethyl esters, the proportion of the quantities of the three isomeric mononitro-derivatives, which are formed at the same time, varies with the temperature (−30°, 0° and +30°).—Prof. van de Sande Bakhuyzen presented, on behalf of Mr. H. F. Zwiers, a paper on the system of Sirius according to the most recent observations.

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THURSDAY, JULY 6, 1899.

## *MAMMALIAN DISTRIBUTION.*

*The Geography of Mammals.* By W. L. and P. L. Sclater. Pp. xviii + 335. Illustrated. (London: Kegan Paul, Trench, Trübner, and Co., Ltd., 1899.)

THIS work may be best described as being of an extremely conservative nature; so conservative indeed that the authors seem under the impression that scarcely any improvement or alteration in views advanced many years ago can by any possibility be rendered necessary through the general progress of science and the work achieved by other investigators. It may likewise be described as a unionist production, for, in addition to the names of the two authors which appear on the title-page, we are told in the preface that two other gentlemen have assisted in the compilation of the lists of genera. Unfortunately, although there has doubtless been "a union of hearts," a union of pens is conspicuous by its absence; so that, as will be shown in the course of this notice, there are many glaring incongruities between different portions of the work, while the want of correspondence in the nomenclature employed can scarcely be designated as anything less than appalling.

The work really consists of three distinct sections. First, we have seven chapters by Mr. W. L. Sclater on the terrestrial regions into which the globe may be mapped out from the distribution of its mammals. Secondly, there is a chapter by the senior of the two authors on the marine regions indicated by the distribution of cetaceans and sirenians. And, thirdly, the seven last chapters of the book, by the same hand, treat of the distribution of the various orders of mammals.

As the results of their investigations, both from the strictly geographical and the purely zoological standpoint, the authors are convinced that the regions originally proposed by the senior of the two, chiefly on the evidence of passerine birds, are also, in the main, those best adapted to show the present distribution of mammals. For reasons which will be apparent to many of his readers, the present reviewer has no intention on this occasion of recapitulating the arguments which have been used against some portions of this grouping. It will suffice to say that he does not agree with them; and criticism may well be left to American zoologists, who may be trusted to fight strongly in defence of their own views, which receive, if we may say so, somewhat scant justice at the hands of the Messrs. Sclater. Taking, then, the groupings of the regions as they stand, attention may be concentrated on some of the details of the book before us.

Perhaps the most satisfactory feature of the book is the prominence given to the three primary divisions—Arctogæa, Neogæa, and Notogæa—into which nearly all authorities are agreed that the land surface of the globe should be parcelled out from a distributional point of view. We should, however, have much preferred seeing these great divisions indicated in the general map forming the subject of Plate I.; and the component "regions" into which the first is subdivided marked by colour-shadings. As it is, the essential difference between the single regions respectively constituting the two latter divisions and those included in the first are totally unapparent. One very distinct improvement on all previous works on the subject we are happy to recognise. This is the separation of Celebes from the Australian and its transference to the Oriental region. But we think the authors have scarcely gone far enough, and that Timor and the Moluccas might likewise have shared in the same westerly shift. In any case, it seems scarcely justifiable to retain the term "Wallace's line" solely for the small channel separating Bali from Lombok, seeing that it is generally taken to include the one between Borneo and Celebes.

Admitting that the authors and the present reviewer "agree to differ" in regard to the number of regions, the work would have had a greater value had it been a thoroughly up-to-date and trustworthy *résumé* of what we take leave to call the old-fashioned view. But is this really the case? As is stated in the preface, the seven chapters by the junior author first made their appearance in the *Geographical Journal* between the years 1894 and 1897. They are now reprinted "with some slight alterations." Bearing in mind the rapid movements of science in all its branches, to which allusion is likewise made in the preface, is it, we ask, fair to the author himself and the public at large to make what may have been very good in its way in 1894 do duty in 1899?

To take one instance out of many, we find it stated on pp. 53 and 54 that "there can be *no doubt*[1] that the Galapagos have never, at any period of their history, been joined to the mainland." Now, so far back as 1892 (so that, by the way, the statement might have been included in the original paper) the late Dr. George Baur[2] wrote the following sentence:—"That it has been made probable that the Galapagos are of *continental* origin, I consider one of the most important results of the expedition." And this view Dr. Baur has subsequently endeavoured to develop in not less than five separate communications. Of course the authors have every right to take their own view, but they have no justification either to ignore the existence of an opposite opinion, or for the use of the words "no doubt."

Dogmatism is indeed much too apparent throughout the book. For example, on p. 217 we find the statement (by the senior author) that certain views

"would tend in favour of the now generally accepted doctrine that the principal masses of land and water are not of modern origin, but have existed in *their present shapes throughout all ages.*"

In regard to this astounding statement, we may well ask whether the author is acquainted with a work which has attained some celebrity on the continent—to wit, the second edition of Neumayr's "Erdgeschichte." If not, his attention may be directed to the map on p. 203 of the second volume; and if he can say that the continents then retained "their present shapes," he evidently puts a different interpretation on the word shape than the one to which we are accustomed.

But without the aid of foreign works the author may,

1 The italics in this and other quotations are the reviewer's.
2 Proc. Amer. Antiquarian Soc for 1891.

we think, in this connection be "hoisted with his own petard." On turning to pp. 236–7 we find the following statement :—

"This fact would seem to show that the ancient 'Lemuria,' as the hypothetical continent which was originally the home of the Lemurs has been termed, *must* have extended across the Indian Ocean and the Indian Peninsula to the further side of the Bay of Bengal and over the great islands of the Indian Archipelago."

Is this quite a case of the retention of their present shapes by the continents?

But there is more to be said in regard to this paragraph, and especially in respect to the use of the objectionable *must*. Turning back to pp. 149–50, we find the junior author discussing the theories that have been advanced as to a direct communication between Africa and India across the Indian Ocean. As the result of his own criticism we have the following very definite statement :—

"This land connection may be of use in explaining the distribution of some of the lower vertebrates, but is of *no assistance so far as the Mammals are concerned;* because in those early times it is probable that none of the families or even orders of our present Mammals had arisen."

And yet in the passage previously quoted we are calmly told by the senior author that the old home of the Lemurs *must* have extended across the Indian Ocean! Comment is superfluous!

Possibly if this were a single isolated instance it might be passed over as one of those unfortunate slips to which the most careful of us are occasionally liable. But it is by no means so; and, out of several others, we select another instance.

On p. 216 Dr. Sclater, in treating of seals, writes that

"In former ages there must have been some barrier in the Atlantic which did not exist in the Pacific to stop their progress northwards. The only barrier one can imagine that would have effected this must have been a land uniting South America and Africa across which they could not travel."

Apart from the question whether such a barrier accords with the dictum as to the retention of their shape by the continents at all periods of the earth's history, we find Mr. W. Sclater making the following very definite statement on p. 55 :—

"Everything points to the conclusion that during a long geological age, probably *throughout the greater part of the Tertiary period*, *South America* was entirely *isolated* from the rest of the world."

If, therefore, an Atlantic barrier stopped the northward progress of the seals, it must have existed, at the very latest, in the Lower Eocene period; and at present we are unaware of the existence of seals previous to the Miocene!

The truth is (and there are occasions when plain-speaking is necessary) neither of the authors, nor the two gentlemen who have assisted them, have the slightest practical acquaintance with palæontology, and (to use a word "made in Germany") *erdgeschichte*. And they would have been well advised had they left such subjects severely alone, and made what they could out of the present distribution of animals. That a true geographical scheme of distribution can be made on such knowledge alone we are not prepared to admit; but that is a detail.

As an example of palæontological ignorance, we may refer to the twice-repeated statement (pp. 189 and 195) that fossil camels are unknown in Europe; and yet one from Rumania has been described some time since. Again, on p. 80 we are told that opossums occur in the Santa Cruz beds of Patagonia; and here, as well as on p. 9, they are consequently regarded definitely as members of the endemic South American fauna. And yet on p. 156 it is stated that the Virginian opossum "may be a survivor rather than an intruder in North America." On p. 323 we meet with the statement that whether the same animal is certainly indigenous in North America, "or whether it may not have extended its range northwards from Central America in more recent times, it is hard to say." All this confusion arises from insufficient acquaintance with the facts; what we believe these to be need not be mentioned here.

Allusion has already been made to the want of reference to modern literature in the case of the Galapagos islands, and this is also noticeable in other cases. For instance, what can be thought of the omission of all reference to Dr. Merriam's papers on distribution in the introductory chapter? Here, too, mention should have been made of Mr. Pocock's distribution of Arachnida, seeing that it takes much account of other groups. Mr. Baldwin Spencer's important observations on the origin of Australian Mammals, published in the "Results of the Horn Expedition," are likewise unnoticed; as are those of Dr. Schärff on that of the European fauna. Somewhat curiously, too, a small work published a few years ago on mammalian distribution, which has been deemed worthy of translation into German, likewise receives no recognition.

In addition to all the foregoing (to say nothing of other) inconsistencies and omissions, the present work is, unfortunately, open to very severe criticism on account of carelessness in proof-reading, and the lack of correlating the names used in the later pages with those that precede them. Since the book appears to be written to a certain extent for amateur zoologists, these errors are the more to be deprecated. To quote all that we have detected would be impossible, and a few must accordingly suffice.

To the beginner it will be decidedly puzzling to reconcile the statement on p. 2, that mammals may be divided into eleven orders, with the one on p. 219 that the number of such divisions is fourteen; more especially as the monkeys are classed under the name Primates in the one place, and as Quadrumana in the other. Again, the uninitiated will be somewhat disconcerted to find the dormice figuring as *Myoxidae* on p. 182, and *Gliridae* on p. 276. Neither is it conducive to clearness to find the Picas described as *Lagomys* on p. 166, *Ochotoma* on p. 274, and *Ochotona* on p. 281. Minor discrepancies in the spelling of family and generic names, such as *Phyllostomatidae* on p. 265 against *Phyllostomidae* on p. 269, *Pteropidae* on p. 64 against *Pteropodidae* on p. 161, and *Haplodon* on p. 159 against *Haplodontia* on p. 272, are so numerous that the corre-

spondences are almost in a minority when compared with the discrepancies. More serious is *Hydropotes* on p. 139 against *Hydrelaphus* on p. 296. But the culmination is reached when we find, pp. 115–6, *Otocyon* twice identified with the Cape hunting-dog, and, p. 313, the giant *Armadillo* miscalled the giant *Kangaroo!*

With regard to the authors' view on nomenclature, which we venture to regard, with certain curious exceptions, as somewhat old-fashioned, it is not our intention to offer any general criticism on this occasion. We may, however, point out that in rejecting the earlier *Mazama* in favour of the later *Cariacus* for the name of the American deer, they are led into a difficulty when they come to sub-genera; *Dorcelaphus* (a sub-genus) antedating *Cariacus* (the genus)! Moreover, whereas they term the guemals *Xenelaphus* on p. 297, the same animals are designated *Furcifer* on p. 78.

With the statement that the chapter on marine regions is a new feature in books of this nature, and that those by Dr. Sclater on the distribution of the various mammalian families and genera will be found of the greatest value to students, the latter half of the book must be dismissed without further notice.

A large number of figures, for the most part specially prepared for it, illustrate the volume; and to the excellence of these we are glad to be able to testify. The maps, too, which are numerous, are all that can be desired to illustrate the text. And here it may be mentioned that in the majority of instances the sub-regions are well determined, and their distinctive faunas well described. The portion of the work relating to these must, indeed, claim a high value for students. We cannot, however, but regret that the authors have not seen their way to follow Mr. W. T. Blanford in the recognition of a Tibetan sub-region, the animals of that area being of so remarkably isolated a type.

Throughout the foregoing criticisms it will be noticed that we have studiously avoided bringing forward our own views, and have been content to call attention to the discrepancies and misstatements in those of the authors. Had the authors taken more pains in bringing their subject up to date, and did they possess (if we may say so) the all-round knowledge necessary to the proper fulfilment of their task, the volume, as an expression of what we regard as somewhat old-fashioned views, might have been worthy of higher commendation than we can venture to bestow.

R. L.

## ANTIQUITIES FROM BENIN.

*Antiquities from the City of Benin, &c., in the British Museum.* By C. H. Read and O. M. Dalton. Pp. 61 + Plates 32. (London: British Museum, 1899.)

THE real interest in the finding of the Benin bronze castings centres in the fact that a negro people seem at one time to have been able to produce bronze work showing great skill in manufacture, coupled with indications of a considerable amount of knowledge of art. The question how the craft was learned immediately suggests itself. Messrs. Read and Dalton appear (p. 16) to accept the statement of the natives (p. 6) that it was introduced by the Portuguese, but further on (p. 19) they acknowledge that it is "not easy to solve how far Europe is responsible for the art of metal casting in West Africa." From what may be called internal evidence, we may reasonably suppose that some of the best castings date back to the end of the fifteenth or the beginning of the sixteenth century. If the Portuguese introduced the art we should expect that some specimens of Portuguese work of that date, and of equal merit, should be found in our museums. So far no such evidence is forthcoming. There is, however, no reason why the art should not have been in existence before the arrival of the Portuguese amongst the Bini in the same way as the domestic architecture in Benin and the surrounding country is most probably indigenous, or in the same way as the decorative art of the Ashantis is indigenous in so far as our knowledge goes. In all probability, the solution of the question will be found to lie in the fact that the existence of the art antedates the arrival of the Portuguese, who, however, may have given it considerable impetus. Yet it must not be taken for granted that the Portuguese were the only people who influenced the art, for there is plenty of evidence pointing to other influences, and we can rest assured that, amongst a people so fond of trade as the African negroes, trade objects would be numerous, and these would leave their impress behind them. For instance, an almost exact copy of a spiral bracelet from Benin was brought many years ago from Tunis, and is now in the Blackmore Museum, while its prototype is to be found at the present day on the banks of the Upper Congo.

From a time shortly subsequent to the arrival at the British Museum of the large collection of these bronze castings, the authorities prohibited any student from taking notes, on the plea that they intended to publish a work on the collection. The work is now before us. It consists of an historical introduction with a descriptive summary, for purposes of comparison, of the Yoruba gods taken from Burton instead of from Ellis's later and more comprehensive account, a chapter each on the ivory work, the metal work, the early Europeans, and on dress, ornament and weapons, as exemplified by the specimens in the collection. The illustrations are fair, but some—as, for instance, those of the ivory tusks and a king's or chief's helmet—are reproduced on too small a scale to be of much assistance to the student. It is to be regretted that the authors have limited themselves to deal solely with the specimens in the British Museum collection. The museum possesses a unique collection of the bronze castings used as historical or decorative plates on the pillars of the king's compounds, but it possesses very few of the numerous domestic and other utensils, many likewise unique, which have from time to time been on sale in London. In other words, the collection is not a representative one, as is, for instance, that of General Pitt-Rivers at Farnham. The opportunity for a comparative study of the objects *inter se* is impossible, and the student will therefore have to go to other museums to complete his studies. However, even restricted as the work is in its scope, the monograph will always be found useful, and the authors are to be congratulated on a good piece of work.

H. LING ROTH.

## THE LOST VOLUME OF HUTTON'S THEORY OF THE EARTH.

*Theory of the Earth, with Proofs and Illustrations.* In four parts. By James Hutton, M.D. and F.R.S.E. Vol. iii. Edited by Sir Archibald Geikie, D.C.L., F.R.S. (Geological Society, Burlington House, 1899.)

AS we learn from Sir Archibald Geikie in his interesting preface, the history of the later portion of James Hutton's great work on the "Theory of the Earth" is a perplexing question. In 1795 the well-known two volumes appeared, containing the first and second parts, but the title-page bears the words "in four parts." Of those two the first is little more than a reprint of the essay on the same subject read to the Royal Society of Edinburgh in 1785. The second part, dealing with the operation of natural causes on the surface of the globe—or dynamical geology, as it is now sometimes called—was new matter. These volumes are without preface or preliminary sketch, so that no clue is given to the plan of the remainder of the work, while the fact that Hutton ends his second volume with an elaborate summary suggests that he contemplated a pause of some duration before issuing the remainder. At his death, in 1797, the third volume, according to Playfair, was practically complete; and we do not know why his friends did not publish it. Perhaps, as Sir A. Geikie suggests, they waited for certain illustrations, which Mr. John Clerk, Hutton's great friend, had promised to furnish. Gaps are left for these in the text; but, at any rate, Playfair and Lord Webb Seymour quote from the manuscript in a paper on Glen Tilt, read to the Royal Society of Edinburgh in 1814. It was then lost sight of—the earlier portion, including three chapters, has vanished; the other was a parting gift from Lord Webb Seymour to Leonard Horner, and was presented by him to the Geological Society of London in 1856. In its charge it has remained, forgotten by most of the Fellows, till Sir Archibald Geikie urged its publication on the Council, promising to take upon himself the laborious task of editing. Needless to say, this has been admirably done. The manuscript is printed as though it had followed on the preceding volumes. A few small lacunæ or matters needing explanation are dealt with in explanatory notes, which are models of terseness and a great help to the reader, who, in addition, has to thank the editor for an index, not only to this volume, but also to the two others.

This fragment of a geological classic is well worth the cost of publication. Three of its six chapters are more or less controversial, and are thus, to some extent, obsolete, though it is always interesting to see how difficult problems were viewed by the greater intellects in the infancy of the science. But the other three chapters, descriptive of geological journeys in the Highlands (including the famous examination of Glen Tilt), in the Southern Uplands, and in the Isle of Arran, retain their vivacity and freshness though a full century has passed since they were penned. They also demonstrate Hutton's power as a field geologist, and thus help to refute the reproach which has sometimes been levelled at him of being a mere speculator. Besides this, they show that he could describe accurately and reason profoundly in the ordinary English tongue; and this is not the least charm in days when geological writing is apt to become a conglomerate of scientific jargon unintelligible to all but specialists. Fragment though it be, this volume has an interest and value all its own, and our best thanks are due to both the learned editor and the Council of the Geological Society, for "The Theory of the Earth" is one of the chief foundation stones of modern geology. We trust that the attention thus drawn to "Volume iii." may bring about the discovery of the manuscript which is still missing.

T. G. BONNEY.

## OUR BOOK SHELF.

*Animals in Motion. An Electro-photographic Investigation of Consecutive Phases of Progressive Movements.* By E. Muybridge. Pp. 264 + 1600 half-tone Pictures. (London: Chapman and Hall, Ltd., 1899.)

MR. MUYBRIDGE'S book, "Animals in Motion," with its numerous illustrations, offers a most interesting study, not only to the physiologist, the man of science, and to lovers of animal nature, but also to the artist and archæologist. Mr. Muybridge's attention was first directed to the movements of animals in the year 1872, while directing photographic surveys of the United States Government on the Pacific coast, by a controversy concerning animal locomotion which was being carried on in San Francisco. Mr. Muybridge tells us that according to Plato the same subject was warmly argued by the ancient Egyptians. (This statement is not verified by a reference, and it is improbable that the point is mentioned by Plato.) Mr. Muybridge determined to settle the question whether, in trotting, the horse ever had the four feet simultaneously off the ground. By an ingenious arrangement of electrically controlled cameras, Mr. Muybridge discovered and definitely proved that the trotting horse, in certain phases of his movements, has all four feet off the ground at the same time.

Mr. Muybridge became so fascinated with the new subject, namely animal locomotion, that he studied and photographed the movements of men, women, children, lions, tigers, and other animals both wild and domestic, and also the flight of birds. His book contains a series of most beautiful and interesting pictures, each illustrating some feature of movement. Of these, probably the most instructive are those of the child crawling (p. 69) and the baboon walking (p. 75). The pictures he obtained show the exact positions of the legs and feet of the animals at certain definite times. The other motions of the horse, namely the amble, the trot, the canter, the gallop, and some more, are carefully analysed by the electro-photographic method. In the fourteen series pictures of the trot, 2 and 19 (p. 107) show the four feet off the ground at the same time; these are the pictures which entirely settled the question which fortunately started Mr. Muybridge on his excellent work; the series was photographed at Palo Alto in 1879. The series on p. 229 of the mule "Ruth," bucking and kicking, show that the animal adds marked rotation of the hind-quarters to movements which, in themselves, must be terrible to the rider. In addition to the electro-photographic analysis of the movement of animals, the author devised an instrument whereby a series of pictures was recombined, and by it a life-like picture of a moving animal was projected on to a screen. The instrument is called the Zoöpraxiscope; it is in a large degree similar to the old Phenakistiscope, made by Dubosq of Paris, by means of which moving pictures were projected on to a screen at the old Polytechnic Institution ("Play-book of Science," by J. H. Pepper, 1864). From beginning to

end Mr. Muybridge's electro-photographic analysis of the movement of animals is excellent, and his results have been reproduced with great clearness of detail.

F. J. J.-S.

*Sanatoria for Consumptives in various Parts of the World.* By F. Rufenacht Walters, M.D., M.R.C.P. With an Introduction by Sir Richard Douglas Powell, Bart. Pp. 374; Illustrations 41. (London: Swan Sonnenschein and Co., Ltd., 1899.)

THIS book represents the result of a most painstaking inquiry on the part of the author into the institutions for the treatment of consumptive patients. The various sanatoria are described with a great amount of detail, more especially with regard to situation, charges, access, &c. The actual information with regard to the details of treatment is, however, scanty. Phthisical patients differ so widely *inter se* that of course anything approaching a sanatorium diary, even had it been given by Dr. Walters, would only have been of general interest. Presumably the book is intended for the professional and lay reader—both these may confidently rely upon getting much information from it with regard to the possible places for treatment; but the practitioner who intends initiating a so-called open-air treatment, of which we have heard so much and seen so little, will find considerable difficulty in getting the practical information he wants from Dr. Walters' book. He will do better to consult the earlier works of Brehmer and Jaruntowsky. Those, however, who want to build a sanatorium will do well to thoroughly master Dr. Walters' book, and especially the plates which he gives of the most known sanatoria abroad.

The book will doubtless be a surprise to many English professional readers, who probably have no idea to what an extent the sanatorium treatment has progressed abroad, and especially in Germany. It will probably also have a very wide sphere of usefulness in showing the physician where he can have his patient treated at most moderate cost in the most enlightened manner. No one can doubt that the best advice which at present could possibly be given to many phthisical patients only scantily endowed with this world's goods would be to go to such a place, for instance, as Görbersdorf, where, for from 2*l.* to 4*l.* per week they can have everything they can possibly want—a skilled and patient doctor, suitable food, climate, and accommodation. By indicating clearly the relative merits of such institutions, Dr. Walters has performed a service for which the medical profession ought to be grateful.

F. W. T.

*Measurement and Weighing.* By E. Edser, A.R.C.S. Pp. vi + 111. (London: Chapman and Hall, 1899.)

THIS small manual is intended as a guide for teachers engaged in instructing classes of young students in the first principles of practical physics. As the author states in the preface, only a limited field has been chosen for consideration, and this has been intentionally treated with more than the usual amount of detail. This has been done with the object of showing, from more than one point of view, the applications of the various principles involved.

In Chapter i., "Linear and Angular Measurements," the pupil is led from the actual copying of a standard scale to the different uses of it in determining the dimensions of various objects, first approximately, then as accurately as possible. Most of the experiments in this chapter are original and, although simple, are evidently calculated to induce thought in their working out. Chapter ii. deals with "Superficial and Solid Measurements," introducing the usual problems of mensuration in a practical manner.

In Chapter iii., after describing the trigonometrical functions and ratios, the author gives a very ingenious and novel method of graphically determining the logarithms of numbers, by means of which the student can make himself independent of tables.

The concluding chapter consists of a very clear and detailed experimental exposition of the principles relating to "Mass and Density."

The system adopted has been actually followed in class teaching, and will no doubt be helpful to others in the arrangement of their experimental courses.

*Die physikalischen Erscheinungen und Kräfte.* By Prof. Dr. Leo Grunmach. Pp. viii + 442. (Leipzig: Otto Spamer, 1899.)

IN this volume the author brings before the reader a popular and accurate account of the greater number of physical phenomena and forces which are more or less commonly met with in every-day life. The book is intended for those readers who wish to gain a general insight into common physical matters and phenomena without being troubled with a too detailed account which would necessitate a more minute study.

Commencing with the definitions and means of determining mass and measurements, the author successively deals with the principles involved in and phenomena connected with sound, light, heat, magnetism, electricity, &c., concluding with most of the more recent discoveries, such as Röntgen rays and Marconi's system of telegraphy.

The contents of the book are far too numerous for us to deal with in a few words, so we must be content to point out that the text is profusely illustrated with well-chosen woodcuts, a special feature being a set of portraits of notable scientific men. We may mention here that on p. 143, in the chapter on spectrum analysis, it was intended to give the portrait of Sir Norman Lockyer; but although the illustration is coupled with his name, the portrait is that of Sir William Flower.

Not only should the book be read by those who wish to know something about natural phenomena and forces, but it should be useful to students who desire to make themselves acquainted with the German language.

*Practical Plane and Solid Geometry (Test Papers).* By George Grace, B.Sc., A.R.C.S. (London: Macmillan and Co., 1899.)

THIS publication consists of a series of twenty-four graduated test papers selected chiefly from the annual examination questions in the elementary stage of geometry of the Science and Art Department. Each exercise contains six problems, and being printed on cartridge paper the solutions may be worked out directly on the sheets under their respective headings. This feature should be specially commendable to teachers of large classes, as the uniformity of the arrangement of the questions and the size of the sheets will be found of considerable help from an examiner's point of view.

*Practical Dictionary of Electrical Engineering and Chemistry in German, English and Spanish.* By Paul Heyne, assisted by Dr. E. Sanchez-Rosal. Vol. II. English-Spanish-German. Pp. vii + 209. (Dresden: Gerhard Kühtmann. London: H. Grevel and Co., 1899.)

THE difficult task of preparing a technical trilingual dictionary has been accomplished in the present case with commendable accuracy. The Spanish and German equivalents are given of a large number of technical terms used in engineering, modern machine industry, metallurgy, electricity and chemistry, and other applied sciences. To the engineer, the student of physical science, and the commercial man, the dictionary should prove of great service.

## LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### Magnetic Strain in Bismuth.

YOUR report of the meeting of the Royal Society of Edinburgh, held on May 16 (NATURE, June 22, p. 192), states that Dr. C. G. Knott has obtained a slight indication that there is a change of form in bismuth when strongly magnetised.

In the *Phil. Trans.*, vol. clxxix. (1888) A, p. 216, I described an experiment in which a rod of bismuth was found to exhibit an elongation of about 1·5 ten-millionths of its length in a magnetic field of 840 C.G.S. units. As to the reality of this effect and the fact that it was due solely to magnetism, there was no doubt whatever.

Since the publication of my paper I have repeated the experiment with another sample of bismuth obtained from Messrs. Johnson and Matthey; but though the field was brought up to nearly 1500 units, there was never the smallest indication of any magnetic change of length. An elongation one-tenth as great as that observed in the former case would have been easily perceptible.

After this experience I should hesitate to attach importance to any such observations unless the bismuth employed had been proved by analysis to be free from traces of magnetisable metals.

SHELFORD BIDWELL.

———

MY experiments were made with a bismuth *tube*, the notion being that, as in like experiments with nickel tubes, any existing strain would be much more easily detected by means of secondary volume changes than by means of the direct elongation measurements which Mr. Bidwell so successfully carried out. Mr. Bidwell's warning as to the necessity of having the material pure is well-timed. So far I have taken no special precautions in this direction; but in the improved form in which I purpose repeating the experiment, and from which I hope to get some really decisive result, this question of freedom from traces of strongly magnetic metals must of course be carefully considered.

C. G. KNOTT.

### Gooseberry Saw-fly.

I SHALL be obliged if any reader of NATURE who has happened to pay attention to the gooseberry saw-fly will let me know whether my experience agrees with that of observers in other parts of the country. In Yorkshire the larvæ were so abundant in 1893, 1894 and 1895, that the bushes were in many places stripped of their leaves every summer. In 1896, there was a marked diminution, and many of the larvæ contained ichneumons. In 1897, 1898 and 1899, they have been so scarce that I have had difficulty in getting specimens for anatomical study.

L. C. MIALL.

The Yorkshire College, Leeds, June 29.

### School Laboratory Plans.

REFERRING to Mr. Richardson's letter (p. 199), our laboratory, now approaching completion, will afford, as regards chemistry in a room 30 by 26 feet, accommodation for twenty-seven boys, including one 18-foot bench for general purposes, and two draught cupboards. We have one 21-foot wall bench and two 18-foot double central benches in parallel, and one 10-foot wall bench at right angles. I believe a novel feature to be the demonstrator's platform placed on the top of and slung across the central benches, provided with a revolving chair and a table, and approached by steps. The whole sacrifices two working places only. The demonstrator has sixteen boys in front of him, five parallel with him, and six behind him, at a maximum distance of fifteen feet. His commanding position should save considerable time usually spent in running about. A large mirror might further aid matters. The central benches alone have reagent shelves.

A. E. MUNBY.

Felsted School, Essex.

## ILLUSTRATIONS OF MIMICRY AND COMMON WARNING COLOURS IN BUTTERFLIES.

AN interesting, though brief, paper entitled "Natural Selection in the Lepidoptera" was read by Mr. Mark L. Sykes before the Manchester Microscopical Society on November 4, 1897, and published in the *Transactions* for the year (p. 54). The chief interest of the paper consists, as the author points out, in the eight excellent plates by which it is accompanied. These plates contain a very large number of figures reproduced by a photo-mechanical process from the insects themselves. The author has evidently had at his disposal a very large and complete collection, and having selected a number of very fine illustrations he thus makes them available for all other naturalists.

At the opening of his paper the writer expresses some doubt as to whether the subject is a suitable one for a Microscopical Society; but on this question there need be no hesitation. The microscope is an instrument of the most varied uses, and is necessary in the investigation of this subject among others, for without its aid we cannot ascertain the depth to which mimetic resemblance penetrates into the structure of organisms. The interpretation of these resemblances as due to natural selection implies that they are confined to visible effects, and therefore the microscope should reveal an underlying difference beneath the superficial similarity. Hence a paper which, by describing this fascinating subject, and abundantly illustrating it, directs attention to a promising field for microscopic inquiry, is in every way suitable for the audience before which it was read, and the Manchester Society is to be congratulated upon the broad view it has taken of its subject and responsibilities. The present writer has already commenced the study of mimetic resemblance from this point of view, and has found that the methods by which the transparency which is necessary for the likeness attained in a group of Lepidoptera from South America differ in the most marked degree, although the superficial resemblance is of a very high order (*Journ. Linn. Soc.*, vol. xxvi., 1898, pp. 596–602; plates 42, 43, 44).

The great interest of Mr. Sykes' paper is the abundant illustration which it provides for the two different classes of resemblance often confused together under the name of "Mimicry." A few words on the history of the recognition and suggested explanation of these two classes may be useful, inasmuch as great confusion still exists upon the subject. The theory of mimicry was first suggested by H. W. Bates in his important paper published in the *Transactions* of the Linnean Society for 1862 (vol. xxiii.). He here suggested the idea of a conspicuous, abundant, and specially defended species, serving as the model towards which other comparatively rare and defenceless species are brought by natural selection. His illustrations were taken from the fauna of tropical America, and the explanation was suggested to him by the study of his collection after his return home from his prolonged visit to the Amazon Valley. The theory is of special interest, as it was probably the first great result of the theory of natural selection after its appearance in the *Journal* of the Linnean Society in 1858, and in the "Origin of Species" in 1859. Bates' generalisation was extended by A. R. Wallace to the tropical East (*Trans. Linn. Soc.*, 1866, vol. xxv.), and by Roland Trimen to Africa (*Trans. Linn. Soc.*, 1870, vol. xxxi.). In the first-named paper Bates expressly pointed out that his explanation did not cover all cases of mimetic resemblance, but that there were a very large number of species abundant in individuals, and presumably specially defended, which nevertheless "mimic" each other. Furthermore, this kind of resemblance is as close and detailed as that which the Batesian theory of mimicry sought to explain. For such

cases Bates could only suggest—and Wallace at first accepted the suggestion—that the likeness was produced by some unknown influence connected with locality. In some mysterious way the species were supposed to be made alike as a direct result of life in a common district. No further advance was made until 1879, when Fritz Müller suggested (*Kosmos*, May 1879, p. 100) that the resemblance between relatively unpalatable forms was advantageous in facilitating the education of their young and inexperienced enemies, thus preserving a large proportion of the individuals which would have been necessarily sacrificed if the "warning" pattern of each species were different from that of every other in the same locality. Prof. Meldola translated this paper (*Proc. Ent. Soc.*, Lond., 1879, p. xx.) and argued in favour of the explanation which Wallace also accepted. The same kind of likeness between specially protected forms was shown to exist in the tropical East by F. Moore (*Proc. Zool. Soc.*, 1883), and in Africa by the present writer (Report Brit. Association, 1897, p. 688).

The hypothesis associated with the name of H. W. Bates was believed by a large number of naturalists from the very first, while that due to Fritz Müller was a long time in making its way. Of recent years, however, it has come to the front, chiefly in consequence of the papers of F. A. Dixey (*Trans. Ent. Soc.*, Lond., 1894, 1896, 1897). In these papers Dixey has shown strong reasons for the belief that many examples formerly explained by the theory of Bates are in reality to be interpreted by that of Fritz Müller. The wonderful tropical American groups of remotely allied species with a common appearance, selected by W. F. H. Blandford, assisted by the late Osbert Salvin, from the great Godman-Salvin collection, and exhibited at the Royal Society (1896) and Entomological Society (1897), also tended to deepen the impression which the Müllerian theory was making. It was clear to every one who examined the various groups (lists of the species exhibited are given in *Proc. Ent. Soc.*, Lond., 1897) that the vast majority of the likenesses were between species which are known to be abundant and believed to be relatively unpalatable.

The great interest and value of Mr. Sykes' paper is given by the eight excellent plates which accompany it, reproducing many examples of Müllerian mimicry, and large numbers which are believed by the author and many others also to be still explicable by the theory of Bates. Their full discussion, as far as the facts at present known will allow, would be of great interest and would, in the opinion of the present writer, lead to the conclusion that a considerable proportion, at least, are more probably to be explained on Müllerian lines. The examples in the first two plates are almost without exception admitted to fall under the Müllerian theory, and they are described as "Mutual Protective Resemblance of Inedible Butterflies." All the examples are selected from tropical America, and supply a permanent record of many of the members of the groups selected by Blandford.

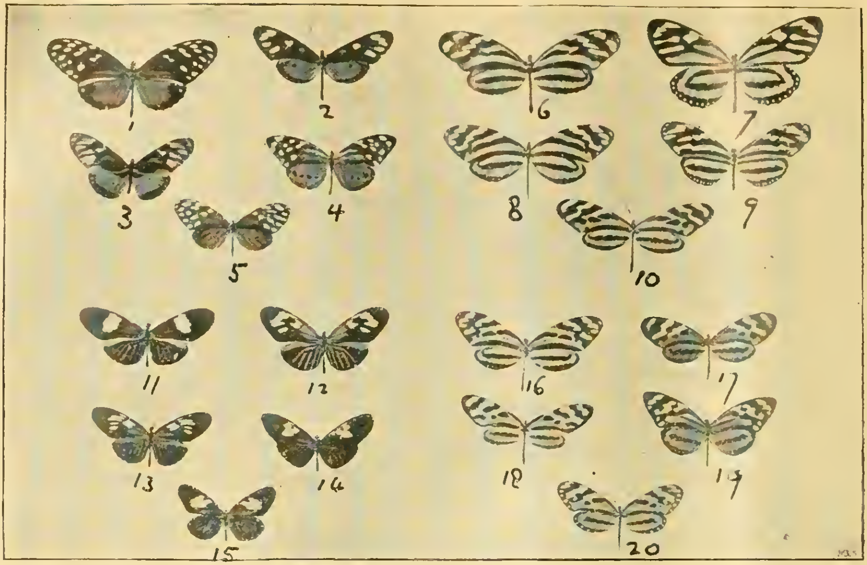
Plate II. is here reproduced, and will serve well to show the closeness of the likeness which is attained, as well as the composite nature of the groups. That containing Figures 6 to 10 is the most interesting in this respect, containing as it does representatives from three distinct sub-families, all of which are believed to be unpalatable—the *Danainae*, *Ithomiinae* and *Heliconinae*. A few errors which have crept into the description of the figures have been set right in the present reprint. (Fig. 6 is that of *Heliconius telchinia*, not of *Eueides zorcaon*; *Eresia*, Fig. 15, belongs to the *Nymphalinae*, not the *Pierinae*.) The distinction between the *Ithomiinae* and *Danainae* is now generally recognised, and has been introduced. A few of the species, viz. those named in Figs. 3, 4, 11, 14, 15, 19, and 20, are insufficiently represented or altogether absent from the collection with which the plate has been compared. Hence the present writer cannot feel confident that these identifications are correct.

In the third plate the well-known resemblance between the three forms of female of *Hypolimnas misippus* (*Nymphalinae*), with its very different male, and the three forms of *Limnas chrysippus* (*Danainae*) are well shown by many examples; but the author has fallen into the error which has often been made before (among others by the present writer), of stating (p. 61) that the forms completely correspond in the various parts of their range. The following statement is, it is believed, all that we are justified in making. In the tropical East (India, &c.), *Limnas chrysippus* is rarely represented by any but the typical forms, with amber ground colour, paler than in Africa, and black and white tip to the fore-wings; the form with white hind-wings (*alcippoides*) is rare, and that without the black and white tip (*klugii*) much rarer still. On the other hand, the two latter forms of the mimicing female are not uncommon, especially the latter. At Aden all three forms of both model and mimic occur together commonly. In North-east Africa the chief forms of the Danaine are the normal and the *klugii*, the white-winged form also occurring more rarely. In Somaliland the *klugii* form seems to predominate; out of several dozen specimens presented to the Oxford Museum by Mr. C. V. A. Peel, and captured in two visits, not a single form except *klugii* is present. The few female *H. misippus*, on the other hand, are normal, and so a marked want of correspondence is revealed. Passing down the east of Africa to the south, *klugii*, at first abundant, becomes gradually rarer, until in the south it is extremely rare. In the female *misippus*, on the other hand, the form *inaria*, resembling *klugii*, is commonly intermingled with the typical form right down to the south. The white-hind-winged form of both model and mimic have a more parallel development occurring not uncommonly in both species. In tropical West Africa, on the contrary, the Danaine butterfly is always white-hind-winged, and the size of the white area is large (constituting true *alcippus*), while the very few females of *H. misippus* which I have seen from this part of the world were normal. Much more evidence is required before the relationship can be made out for all parts of the extremely wide range which these two species have in common. I have here set down the conclusions which seem to be warranted by the facts at present known, in the hope that others may be induced to publish, or at least to make their observations known to the present writer.

To summarise the facts set forth above, the varieties of *Limnas chrysippus* are more definitely restricted to certain localities than those of the female *Hypolimnas*, which is in all localities apt to be a more variable insect; furthermore, intermediate forms between the varieties are commoner in the latter than in the former. In the case of those localities where there is a marked restriction of the forms of *chrysippus* (Somaliland and tropical West Africa), there is no evidence of any equal restriction of the varieties of its mimic.

The figure of a white-hind-winged *alcippus*-like female *Hypolimnas* from Sierra Leone (Fig. 8) appears to have been taken from a not very perfect drawing, while all the other figures on all the plates are excellent reproductions from the specimens themselves.

In the brief but useful memoir which accompanies these plates, the principles of mimicry are described, and many of the figured examples alluded to. In describing the distribution of the varieties of *Limnas chrysippus* which has been here summarised, the author states that the uniformly coloured *dorippus* (*klugii*) is supposed to be the ancestral form. The immensely predominant mimicry of the type form by butterflies and moths belonging to all kinds of remotely allied groups, would, however, indicate with tolerable certainty that the type



Mutual Protective Resemblance of Inedible Butterflies.

| | | | | |
|---|---|---|---|---|
| Fig. ......... | 1 | 2 | 6 | 7 |
| Sub-Fam. ... | Heliconinæ. | Ithomiinæ. | Heliconinæ. | Danainæ. |
| Gen. ......... | *Heliconius* | *Thyridia* | *Heliconius* | *Lycorea* |
| Sp. ... ........ | *zuleika* (Hew.). | *melantho* (Bates). | *telchinia* (Doubleday & Hew.). | *atergatis* (Doubleday & Hew.). |
| Habitat ... | Central America. | S. and Cent. America. | Central America. | S. and Cent. America. |
| Locality ... | Honduras. | Honduras. | Honduras. | Bogota. |

| | | | | |
|---|---|---|---|---|
| Fig. ......... | 3 | 4 | 8 | 9 |
| Sub-Fam. ... | Heliconinæ. | Ithomiinæ. | Ithomiinæ. | Heliconinæ. |
| Gen. ......... | *Eueides* | *Tithorea* | *Melinaea* | *Eueides* |
| Sp. ............ | *thyana* (Feld.) | *irene* (Drury). | *imitata* (Bates). | *dynastes* (Feld.). |
| Habitat ... | Central America. | Central America. | Central America. | Central America. |
| Locality ... | Honduras. | Honduras. | Honduras. | Honduras. |

| | | |
|---|---|---|
| Fig. ......... | 5 | 10 |
| Sub-Fam. ... | Ithomiinæ. | Ithomiinæ. |
| Gen. ......... | *Callithomia* | *Mechanitis* |
| Sp. ............ | *hezia* (Hew.). | *doryssus* (Bates). |
| Habitat ... | Central America. | Central America. |
| Locality ... | Honduras. | Honduras. |

| | | | | |
|---|---|---|---|---|
| Fig. ......... | 11 | 12 | 16 | 17 |
| Sub-Fam. ... | Heliconinæ. | Heliconinæ. | Ithomiinæ. | Ithomiinæ. |
| Gen. ......... | *Heliconius* | *Heliconius* | *Melinaea* | *Mechanitis* |
| Sp. ............ | *venestus* (Salv.). | *vesta* (Cram.). | *lilis* (Doubleday & Hew.). | *veritabilis* (Butl.) (male). |
| Habitat ... | South America. | South America. | South America. | South America. |
| Locality ... | Bolivia. | Amazons. | Venezuela. | Trinidad Island. |

| | | | | |
|---|---|---|---|---|
| Fig. ...... ... | 13 | 14 | 18 | 19 |
| Sub-Fam. ... | Heliconinæ. | Heliconinæ. | Ithomiinæ. | Ithomiinæ. |
| Gen. ......... | *Eueides* | *Eueides* | *Mechanitis* | *Tithorea* |
| Sp. ............ | *thales* (Cram.). | *heliconides* (Feld.). | *veritabilis* (Butl.) (female). | *doubledayi.* |
| Habitat ... | South America. | South America. | South America. | South America. |
| Locality ... | Amazons. | Bolivia. | Venezuela. | Venezuela. |

| | | |
|---|---|---|
| Fig. ......... | 15 | 20 |
| Sub-Fam. ... | Nymphalinæ. | Ithomiinæ. |
| Gen. ......... | *Eresia* | *Ceratinia* |
| Sp. ...... ..... | *cornelia.* | *dionaea* (Hew.). |
| Habitat ... | South America. | South America. |
| Locality ... | Bolivia. | Venezuela. |

form is the ancestral one, just as the conclusion that Africa is the ancestral home of the species is justified by the predominant amount of mimicry of which *D. chrysippus* has been the attractive centre in this as compared with all other parts of its vast range. The time which would be necessary to bring about so deep an impression on so many diverse members of the surrounding insect fauna, justifies the view that the type form has persisted as it is for a very long period, and that it is an extremely ancient inhabitant of the country in which, far beyond all others, these effects are marked.

The statement on p. 61, that the varieties of the female *Hypolimnas misippus* are nowhere found "where the inedible *chrysippus* and its varieties do not occur," is an error. For many years now—certainly between twenty and thirty—the former species has been established in some of the West Indian islands and certain parts of tropical South America.

There are several errors in the spelling of names of species, and the figures in the plates are often wrongly sexed and sometimes wrongly named in the descriptions.

The doubtful points in the paper have been here discussed at some length, and errors of detail pointed out; but the present writer would wish in conclusion again to emphasise the interest of this short communication, and again to draw attention to the usefulness of the numerous illustrations. E. B. P.

## THE UNITED STATES NATIONAL MUSEUM.[1]

THE last report issued by the U.S. National Museum furnishes abundant evidence of the energy with which America is now conducting scientific inquiry, and of the zeal with which she is augmenting the rich and varied collections preserved at Washington. Like most collections of the same character, the National Museum owes its origin to the generosity and enterprise of private individuals; and it was only after some years of precarious existence that it obtained due assistance and recognition from the State. The society organised in 1840, and called the "National Institute," may perhaps be regarded as the parent of the present Museum. Though prosperous during the first few years of its existence, it failed to interest a wide body of the public, and it was reserved for the Smithsonian Institution to obtain official recognition as the only lawful place of deposit for the national scientific collections. In 1846 such recognition was accorded by Act of Congress, and from that year until the present time the work of collecting and exhibiting new material has been carried on without interruption.

One striking characteristic which distinguishes the National Museum from similar institutions in other countries is to be found in the somewhat restricted area to which it has confined its attentions. While the museums of Europe include exhibits from all regions of the globe, the United States collections are, with a few exceptions, exclusively North American. The advantage of so restricting the area of research is obvious, for by this means the Museum has been enabled to attain an unrivalled completeness in the departments of science to which its energies have been devoted. The authorities have also found considerable assistance in the fact that for nearly twenty years they have received all collections of minerals and objects bearing on natural history archæology and ethnology which have been made during the numerous surveys undertaken by the Government of the United States.

The present report occupies over eleven hundred pages, and it would be impossible in a short notice to do more than sketch the general nature of its contents, and to indicate the sections into which it naturally falls. The volume is divided into two unequal parts, of which the first consists of the report of the late Mr. Brown Goode, assistant secretary of the Smithsonian Institution, to which are attached a number of appendices. This report covers the whole ground of the Museum's activities, describing new accessions, the arrangement and labelling of the collections, the work of exploration conducted during the year, the official publications and contributions made to scientific literature, and the work done in connection with visitors and students at the Museum. These general summaries are followed by detailed reports of the work done in the various scientific departments, concluding with the report of the administration department of the Museum. After a perusal of these reports it is evident that, in addition to prosecuting scientific inquiry, the Museum is doing much to render its resources available to the public at large. By its system of exchange and its distribution of duplicate specimens, a large number of local museums in the United States have benefited in the course of the year.

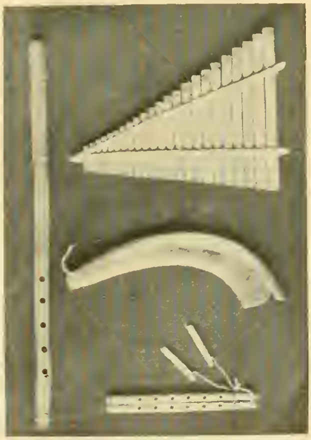


FIG. 1.—Wind Musical Instruments. 1, Reeds or Pan Pipes; 2, Ram's Horn; 3, Double Flute; 4, Flute.

The second and larger portion of the volume is of greater general interest, for it consists of a number of original papers describing and illustrating the collections preserved in the Museum. Of these, perhaps the most important is the paper on "Prehistoric Art" by Mr. Thomas Wilson, the curator of the Division of Prehistoric Archæology. Although in the main describing the specimens under his charge, Mr. Wilson has not confined himself to the art of primitive America, but has given a very exhaustive sketch of the products of early civilisations all over the world, and his essay forms a valuable contribution to the study of prehistoric man. Another interesting paper devoted to a special subject is contributed by Mr. Walter Hough, the assistant curator of the Division of Ethnology, who has written a monograph on "The Lamp of the Eskimo." The Museum possesses a very complete collection of Eskimo lamps, comprising examples used by nearly every tribe from Labrador to the Aleutian Islands. The lamps are

[1] Report of the United States National Museum under the direction of the Smithsonian Institution, for the year ending June 30, 1896. Pp. xxiv + 1107. (Washington: Government Printing Office, 1898.)

classified according to their *provenance*, and full descriptions and illustrations are given of a large number of typical examples.

Two other papers in the volume deserve special mention, as they illustrate another side of the Museum's activities. In addition to their purely scientific work,

FIG. 2.—Colossal Statue of the God Hadad, Gertchin, Northern Syria.

special attention is now being given by its officers to the function of the Museum as an educational institution, and to the popularisation of the collections. At the International Exposition held at Atalanta in 1895, special collections were organised and arranged for the illustration of distinct subjects of study, and the descriptions that were published at the time are here reprinted as a record of the collections that were shown. Of these papers, that on "Biblical Antiquities" is written by Dr. Cyrus Adler and Dr. Cassanowitz, who describe a number of exhibits illustrating the geology, flora and fauna of Palestine, while other exhibits dating from ancient as well as modern times throw valuable light on the text of the Old Testament narratives; one of the plates, for instance, which is here reproduced, is intended to illustrate some of the wind instruments mentioned in the Bible (Fig. 1). Moreover, by means of a fine series of casts, reproduced by photography, the antiquities of Western Asia during the principal periods of Old Testament history are fully represented. Two good specimens of these are here given—a colossal statue of the god Hadad from Northern Syria (Fig. 2), and a bas-relief of a lion chase in the so-called "Hittite" style (Fig. 3), which exhibits many interesting points of resemblance to its Assyrian prototypes. The other paper deals with "Chess and Playing Cards," and consists of a catalogue of games and implements of divination, which were also exhibited at Atalanta. This collection was formed by the Museum in collaboration with the University of Pennsylvania, and it is here described by Mr. Stewart Culin, the director of the Museum of Archæology and Palæontology in that University. We have not done more than indicate the varied nature of the contents of this report, but sufficient has been said to show that the study of science and archæology in the United States is receiving valuable encouragement from the Government, and that the system and methods there adopted compare very favourably with those in many European museums.

## *AN IMPROVED LIQUID INTERRUPTER FOR INDUCTION COILS.*

THE following is a description of an improved form of Wehnelt-Caldwell interrupter for induction coils, devised by the writer in conjunction with Mr. J. C. M. Stanton and Mr. H. Tyson Wolff.

The two electrodes of sheet lead C and D dip into dilute sulphuric acid, contained in the glass vessel A. The electrodes are separated by a hollow glass or porcelain cylinder B, which surrounds the electrode C. This cylinder is closed at the bottom with the exception of a circular aperture E, about three or four millimetres in diameter. Through this aperture projects the small end of the conical glass or porcelain valve F, which by means of the screwed carrier tube H and the milled nut G, can be raised or lowered so as to open or close the aperture to any desired extent. As when the apparatus is at work

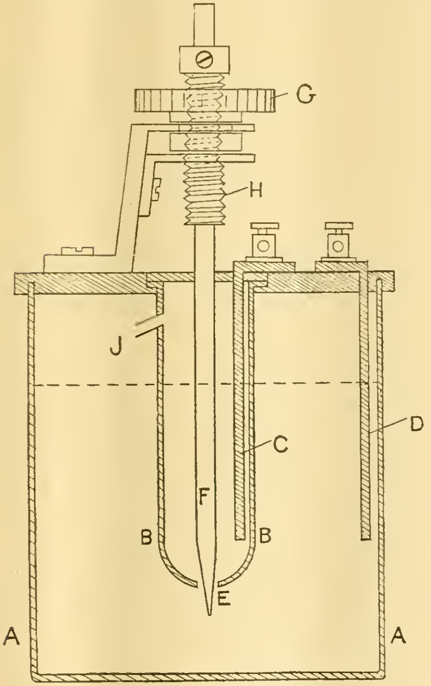
FIG. 3.—Hittite Lion Chase.

the liquid is found to rise in the cylinder B, the latter is provided with an overflow at J.

The interruptions take place in the valve aperture, and appear to be due to the formation of gas or steam therein. The extent to which the valve is open or shut determines the amount of current passed, and the

frequency within wide limits. The wider the valve is open the larger is the current, and the lower is the frequency, and *vice versâ*. With this apparatus in circuit with a 10-inch coil connected direct on to the 100-volt supply mains, it was found that by adjusting the valve the primary current could be altered from 0 to 25 amperes, while the pitch of the sound of the discharge could be changed from a very shrill whistle down to a rattling roar. By introducing additional self-induction into the circuit the frequency can be lowered still further.

The direction of the current through the apparatus does not affect the results, and the arrangement, when suitably adjusted, works well with alternating current, the sparks in each direction being of equal power. The troublesome fatigue phenomena to which the Wehnelt




instrument is liable appear to be absent, while the difficulties as to the fusing of the platinum wire and the cracking of its insulating sheath are also avoided. This improved instrument has in fact all the advantages of that of Caldwell, of which it is a modification, with the further advantage of easy adjustment to suit different voltages, and to give different amounts of power and different frequencies. A. A. CAMPBELL SWINTON.

## THE SEVENTH INTERNATIONAL GEOGRAPHICAL CONGRESS.

AT the meeting of the sixth International Geographical Congress in London in 1895, it was decided that the seventh should take place in Berlin in 1899. The Berlin Geographical Society, according to the precedent of previous Congresses, undertook the necessary arrangements, and these have now been perfected. The Congress will differ from that of London by the absence of a geographical exhibition, and by the more thorough organisation of scientific excursions under specialist leaders before and after the meeting.

The proceedings will commence informally by an evening gathering on Wednesday, September 27, when an opportunity will be afforded for conversation amongst the members. Next day the formal opening of the Congress will take place in the splendid new buildings of the Prussian House of Representatives, which has been generously placed at the disposal of the Congress for the whole meeting. As in London, the proceedings of each day will include a forenoon sitting for the discussion of papers of general interest, and several sectional meetings in the afternoon for subjects which appeal to a limited number of specialists.

The Bureau of the Sixth Congress (of which Sir Clements Markham is President and Dr. Scott Keltie and Dr. H. R. Mill Honorary Secretaries) will present a report and resign its functions to that of the new Congress, the President of which is Baron von Richthofen and the Secretary Hauptmann Kollm. The various committees of the seventh Congress, honorary and executive, bear the names of the most distinguished geographers of all countries, and the gathering promises to be a really representative one.

The papers which have been promised are grouped into seven main divisions, viz. mathematical geography, physical geography, biogeography, anthropogeography, exploration, historical geography, and geographical education. The papers will be very numerous, but as a strict time limit of twenty minutes is to be enforced, there will be an opportunity for effective discussion.

Some of the most interesting subjects to be dealt with in the first group are the position of mean sea-level, the present state of research on the tides, and seismology, while in physical geography Prof. W. M. Davis and Prof. de Lapparent will deal with questions of geomorphology, and oceanography will be treated in great detail in conjunction with polar research.

Dr. Nansen, Sir John Murray, the Prince of Monaco, Prof. Chun (of the *Valdivia* expedition), Profs. Pettersson, Thoulet, &c., have all promised to take part. The plans of the German Antarctic expedition will be explained by Dr. von Drygalski, the chosen leader; while Sir Clements Markham and Sir John Murray will give an account of the progress of the arrangements of the British Antarctic expedition. It is hoped that a general scheme may be agreed upon for simultaneous and strictly comparable observations, so that by combined action the two expeditions will secure the maximum result for their labours.

The distribution of plants will be dealt with by Profs. Engler, Drude and others, while numerous papers on other branches of physical geography are promised.

Under the head of "Exploration," the names of several Germans are announced, but no British subjects have come forward to claim international importance for their journeys.

One feature of the Congress which promises a practical outcome is the prominence which is given to questions of nomenclature. Prof. Richter (of Graz) will propose a systematic terminology for use in research on glaciers; and the terminology and nomenclature of the forms of the ocean floor will be discussed by Profs. Wagner, Krümmel, Voiekoff, and Dr. H. R. Mill. Proposals for the uniform use of the metric system and the centigrade temperature scale in all geographical work will also be put forward.

The scientific excursions, which for the most part precede the meeting of the Congress, have been well organised. The programme has just been issued, giving particulars as to route, leaders, terms, &c., and also containing a list of the best maps and guide-books, and a

bibliography of the scientific literature bearing on each excursion. Most of the excursions start late enough to allow members who have been present at the British Association meeting at Dover to attend them, and they all terminate at Berlin in time for the feast of welcome. They are as follows:—

(1) Siebengebirge, Rhine, Eifel, Moselle, from September 19 to 25, under the guidance of Prof. Bonn and Drs. Philippson and Kaiser.

(2) Taunus, Rhine, Nahe, Lahn, from September 21 to 26, conducted by Prof. Sievers, of Giessen.

(3) The Vosges, from September 21 to 25, led by Profs. Gerland and Weigand, starting from Strassburg.

(4) Thuringia, from September 23 to 27, conducted by Profs. Walther and Regel.

(5) The Island of Rügen, from September 22 to 27, starting from Greifswald, led by Profs. Credner, Cohen, and Deecke.

(6) East and West Prussia, starting from Königsberg, and led by Profs. Jentzsch and Conwentz, from September 22 to 27.

(7) Glacial excursions in the North German Plain will be made to Rüdersdorf, near Berlin, on October 1, and from Hamburg along the Baltic shores, from October 7 to 11, under the charge of Prof. Wahnschaffe and Drs. Keilhack and Müller.

All communications as to the Congress or the excursions should be addressed to "The Seventh International Geographical Congress, 90 Zimmerstrasse, Berlin, S.W."

## *SCIENCE AT THE WOMEN'S INTERNATIONAL CONGRESS.*

THE Science Section of the Women's Congress was held at the Small Hall in the Westminster Town Hall on Thursday, June 29, with Mrs. Ayrton in the chair, in the presence of a large and attentive audience. The proceedings were divided into two classes—the work of women in the physical sciences, and the work for women in the biological sciences. Astronomy was represented by Mlle. Klumpke, head of one of the departments at the Paris Observatory; geology by Miss Raisin, of Bedford College; chemistry by Miss Dorothy Marshall, of Girton College; bacteriology by Mrs. Percy Frankland; and botany and zoology by Miss Ethel Sargant. The work already accomplished by women in these various branches of science was dealt with by most of the speakers, as also the openings for women who desire to take up science as a profession. Mrs. Ayrton, in the course of her interesting and able address, pointed out that there was an important outlet for the work of women at the present time in the manufacture of electrical apparatus, the demand for electrical instruments being so great that manufacturers were not able to cope with it, and an opportunity was now offered for women with the necessary education, energy and capital to start a factory for this purpose. The subject of research work was also discussed, and stress was laid upon the fact that, inasmuch as the majority of students who take up science do so either as an avenue to a degree or with the idea of earning a livelihood by teaching later on, their training was as a rule insufficient and quite inadequate to permit them to undertake independent original work; whilst on the other hand the demands upon their time made by teaching was so great as to leave practically no leisure for higher work, even when they were qualified to do it. Until this condition of things is altered, and until more women are attracted towards science for its own sake, and not as a means to an end, the contribution of women in the shape of original work must necessarily be limited. It was highly satisfactory to find that, in the open discussion which followed, an attempt on the part of two speakers to introduce the question of vivisection from the anti-vivisectionist point of view was not tolerated by the audience, these speakers being refused a hearing. It is not too much to say that the papers contributed were worthy both of their subjects and their authors, and that there was a refreshing absence of the hackneyed comparison of the relative position and intellectual powers of men and women, which has been such a favourite theme with so many speakers at this Congress. The next International Congress of Women will be held five years hence in Berlin.

## *NOTES.*

WE notice with much regret the announcement that Sir William H. Flower, K.C.B., F.R.S., late Director of the Natural History Departments of the British Museum, died on Saturday, July 1.

THE Albert Medal of the Society of Arts for the present year has been awarded by the President and Council to Sir William Crookes, F.R.S., "for his extensive and laborious researches in chemistry and in physics, researches which have, in many instances, developed into useful and practical applications in the arts and manufactures." The Swiney Prize, awarded every fifth year for a work on jurisprudence, has been awarded to Dr. Dixon Mann for his book on "Forensic Medicine and Toxicology."

AT the annual meeting of the Société nationale d'Acclimatation de France the Isidore Geoffroy Saint-Hilaire Grand Silver Medal was awarded to Prof. J. Cossar Ewart, of the University of Edinburgh, for his zebra hybrid work, and to Miss Eleanor A. Ormerod for her work in entomology.

PROF. MOISSAN has been elected a foreign member of the German Electro-chemical Society.

THE Premier of Queensland has announced that he intends to ask the Queensland Parliament to grant 1000*l.* in aid of the proposed Antarctic exploration expedition.

A CIVIL List Pension of 60*l.* per annum has been granted to Mrs. Kanthack "in consideration of the eminent services rendered to science by her late husband, Dr. A. A. Kanthack, professor of pathology in Cambridge University."

AT Berlin, on June 27, Prof. Virchow opened the new pathological museum which bears his name and has been built under his superintendence. It has cost about 560,000 marks, and contains a collection of more than 20,000 specimens, collected almost wholly by Prof. Virchow himself, and representing the history of pathology during the past half-century.

WE learn from *Science* that Mr. Secretary Long has appointed a Board of Visitors to examine and report upon the U.S. Naval Observatory, to consist of Mr. Wm. E. Chandler, Mr. Alston G. Dayton, Prof. Geo. C. Comstock, Prof. Geo. E. Hale, and Prof. Edward C. Pickering.

THE prize of 500 guineas, offered by the Sulphate of Ammonia Committee for the best essay on "the utility of sulphate of ammonia in agriculture," has been awarded by the judges—Mr. J. Bowen-Jones, of Shrewsbury, and Dr. J. Augustus Voelcker, of London—to Mr. James Muir, formerly professor at the Royal Agricultural College, Cirencester; subsequently at the Yorkshire College, Leeds; now County Instructor in Agriculture to the Somerset County Council. Seventy-three essays were sent in.

WE learn from the *Lancet* that the Senatus Academicus of the Clark University, Worcester, Massachusetts, which is about to commemorate the anniversary of its foundation, has invited

Prof. Angelo Mosso to deliver a lecture on a subject specially chosen for the occasion, and dealing with a scientific problem of present and universal interest, and Italy, to judge from her leading organs, professional and lay, is deeply sensible of the honour. Prof. Mosso started for the United States on June 20, and has chosen as his theme "I Processi Psichici ed il Movimento" (the Psychic Processes and Movement).

THE death is announced of Mr. Henry Wollaston Blake, F.R.S., at eighty-four years of age. Mr. Blake was an original member of the Institution of Civil Engineers, of the Institution of Mechanical Engineers, and of the British Association. He was elected a Fellow of the Royal Society in 1843.

THE forty-eighth meeting of the American Association for the Advancement of Science will be held at Columbus, Ohio, on August 21-26, under the presidency of Prof. Edward Orton. The first general session will as usual be held on Monday morning, August 21, when the president-elect will be introduced by the retiring president, Prof. F. W. Putnam, and addresses of welcome will be made by the Governor of Ohio and the Mayor of Columbus. The addresses of the vice-presidents will be given on Monday afternoon, and the address of the retiring president in the evening. The several sections will meet as usual during the week, and Saturday will be devoted to an excursion, probably to the mounds at Fort Ancient, the coal mines in Hocking Valley, and the natural-gas fields. Further information may be obtained from the permanent secretary of the Association, Dr. L. O. Howard, Cosmos Club, Washington, D.C., and from the local secretary, Prof. B. F. Thomas, Ohio State University.

THE annual general meeting of the Marine Biological Association was held in the rooms of the Royal Society on June 28. The president, Prof. E. Ray Lankester, F.R.S., occupied the chair. The Council reported that the laboratory at Plymouth continued in a state of efficiency, and was adequately equipped with the most modern requirements for marine biological research. The investigation of the natural history of the mackerel, commenced last year by Mr. Garstang, had been continued, and a report on the variations, races and migrations of this fish had been published. A systematic study of the physical and biological conditions prevailing in the waters at the mouth of the English Channel had also been commenced, which it was hoped would throw light on the causes which determine the movements of migratory fishes. The examination of the fauna and bottom deposits between the Eddystone and Start Point had been concluded by Mr. Allen, the director of the laboratory, and a report on the subject had appeared in the *Journal* of the Association. Seventeen naturalists and eleven students had worked in the laboratory, in addition to the members of the regular staff. The following were elected members of Council for the year:—President, Prof. E. Ray Lankester; hon. treasurer, J. A. Travers; hon. secretary, E. J. Allen; Council, F. E. Beddard, Prof. F. Jeffrey Bell, G. P. Bidder, G. C. Bourne, G. H. Fowler, S. F. Harmer, Prof. W. A. Herdman, Prof. S. J. Hickson, Prof. T. Johnson, J. J. Lister, D. H. Scott, Prof. C. Stewart, Prof. D'Arcy Thompson, Prof. W. F. R. Weldon.

IT is the opinion of many meteorologists that daily telegraphic reports from Iceland would be of inestimable value in weather predictions for Great Britain and northern Europe. The commercial intercourse with Iceland would, however, evidently not pay the interest on the cost of the cable, and it is only quite lately that the Danish meteorologists have received from business men a proposition, already mentioned in these columns, that makes the project seem at all feasible. The proposition is referred to by Prof. Cleveland Abbe in the *Monthly Weather Review*. It is as follows:—The "Grande Compagnie des Télégraphes du Nord," having its centre at Copenhagen, has undertaken to build and to maintain a line from Shetland, touching the Faroe Islands and ending at Iceland, if an annual revenue of 13,500*l*. is guaranteed for the first twenty years only. The Government of Denmark and Iceland will establish and maintain the meteorological stations and the expense of daily telegraphic bulletins, and will perform the hydrographic work necessary in connection with the laying of the cable, and will also guarantee an annual subvention of 5000*l*. for twenty years. Therefore, all that now remains to be done in order to secure telegraphic communication with Iceland for commercial and meteorological purposes is to secure the remaining annual income of 8500*l*. It is hoped that a large portion and perhaps all of this may be secured by national legislation in the States of Europe and America that are interested in this subject.

IT is announced in *Science* that Mr. Charles H. Senff has given 5000 dollars to the zoological department of Columbia University for purposes of exploration and publication. Mr. Harrington and Mr. Sumner expect, with the assistance of this fund, to make a second expedition to the Nile in search of *Polypterus*. The fund will also be used for the publication of a memoir on the anatomy of *Polypterus*, to be undertaken conjointly by Messrs. Dean, Harrington, McGregor, Strong, Herrick and Prof. Wheeler, of the University of Chicago.

THE inaugural lecture on the possibility of extirpating malaria from certain localities by a new method, delivered by Major Ronald Ross at the Liverpool School of Tropical Medicine, is published in the *British Medical Journal*. According to Major Ross's observations in India, human malaria is not conveyed by mosquitos of the genus Culex, but by members of the genus Anopheles. Species of the former genus are generally able to breed in pots and tubs of water, cisterns, wells, and drains—that is, they seem to prefer artificial collections of water of this character to natural collections, such as rainwater, puddles, and ponds. In the case of the other genus, Anopheles, however, the larvæ are scarcely ever to be found in vessels and other artificial collections of water, but only in natural ponds and puddles. But whether the dangerous mosquitos prove to be confined to the genus Anopheles or not, it appears certain that they breed in puddles, and are not of the common domestic kind. The practicability of eradicating malaria in a locality by the extermination of the dangerous mosquitos in it thus depends on a single question—Do these mosquitos breed in spots sufficiently isolated and rare to be dealt with by public measures of repression? It is to obtain information upon this subject that an expedition to the West African coast is being organised. If it can be shown by accurate investigation that all the malaria in a large town arises from a few small puddles which can be obliterated at small expense, the value of the discovery could not easily be over-estimated.

THE *Meteorologische Zeitschrift* for June contains a brief note of the results of some important observations made by Dr. J. Tuma in seven balloon ascents, for the purpose of obtaining measurements of the distribution of atmospheric electricity in clear weather, and of determining whether the balloon itself received electrical charges. The first question is of purely scientific importance, and the second is of practical interest, as lately the burning of some balloons has been attributed to electrical discharges. The observations show that the positive potential decreases with increasing height; the positive charges are, therefore, accumulated in the lower strata of the atmosphere. During the four last ascents, Dr. Tuma was unable to find that

the balloons were electrically charged. The details of the investigation were published in the *Sitzungsberichte* of the Vienna Academy in March last.

So many attempts have been made to produce photographic pictures in natural colours, that a bibliography of recent contributions to the subject is distinctly valuable. Mr. Philip E. B. Jourdain gives such a bibliography in *Photography* of June 22. His paper supplements similar bibliographies prepared by Mr. Bolas, the chief additions being a fuller account of Edmond Becquerel's work, and abstracts of two important papers by Clerk Maxwell and Lord Rayleigh on different branches of the subject. A number of processes, in addition to those known to most men of science, are described. The bibliography carries the subject to the end of 1898, so Mr. R. W. Wood's process (see p. 119) is not included.

THE property that the locus of the poles of an arbitrary plane with respect to the conics of a Steiner's surface is another Steiner's surface has been investigated by Lie, Koenigs, and Brambilla. In a communication to the *Rendiconto* of the Naples Academy (v. 4), Prof. Domenico Montesano has dealt with the following questions connected with this problem:—(1) In what relation of position are the two surfaces? (2) Whether the relation is invertible? (3) What forms are described by the double lines, the triple point, and the double tangent planes of the new Steiner's surface when the arbitrary plane is varied? In order to answer these questions, Prof. Montesano examines the correlative questions for the surface of the third order with four double points, making these depend on other more general questions relating to a surface of the third order without singularities.

IN the *Bulletin international* of the Cracow Academy, M. P. Rudski applies the well-known problem of the elastic sphere under given surface-tractions to calculate the radial displacements of the earth's surface under the weight of ice-caps. There are strong reasons for believing that during the glacial period large areas of land were submerged, which at the present time are at considerable altitudes above the sea-level, and M. Rudski's object is to test whether these displacements of the shore-line can be accounted for by the distortion of the earth due to circumpolar ice, assuming the total quantity of water on the earth's surface to be constant. M. Rudski considers the test case of uniform ice-caps extending down to latitude 60°, and he assumes the rigidity of the earth to be the same as that of steel. The deformations are different according to whether glaciation exists about one or both poles, the depressions at the poles being respectively 347·1 and 497·8 metres for an ice-cap 2000 metres thick. Moreover, with bipolar glaciation the displacement of the shore at the edge of the ice-caps is negative, while with unipolar glaciation it is positive but smaller. In either case, supposing fiords to extend inwards into the ice-caps, the shore-displacements towards the centre of the caps would be positive.

IT is well known that the influence of a magnetic field in general increases the electric resistance of the rarefied gases, except when the lines of electric and magnetic force coincide. Profs. Elster and Geitel, writing in the *Verhandlungen* of the German Physical Society, describe an experiment showing that a magnetic field has a similar effect on the conductivity imparted to air by the influence of Becquerel rays. Experiments have also been made by the same writers, showing that the observed results were not attributable to any deviation produced in the rays by the magnet, but that Becquerel rays, like Röntgen rays, possess the property of not being deflected by magnetic force.

IN the last number of the *Zeitschr. Wiss. Zool.*, Mr. L. Johann notices certain peculiar epidermal structures occurring at the base of the spines of one of the spiny dog-fishes (*Spinax niger*), which he believes to be luminiferous. They take the form of brown or black spots, which are not shining, and are situated on a dark ground. Although distinctly visible to the naked eye, they are seen better through a lens; and, owing to the nature of the skin, are more clearly displayed in the embryo than in the adult. When sectionised and examined microscopically, they are found to contain pigment. A tropical representative of the same family (*Isistius brasiliensis*) is already known to possess luminiferous properties, and the author therefore considers that the spots in the Mediterranean species have the same function. By a fortunate coincidence, as his paper was passing through the press, Mr. Johann received a communication from Dr. Beer, of the Zoological Station at Naples, stating that a specimen of *Spinax niger* had recently been captured and brought to the aquarium there. Although wounded and in a generally feeble condition, it emitted a distinct luminosity, which would doubtless have been stronger had the fish been in robust health. The author's conclusions as to the function of the dermal spots are, therefore, demonstrated by actual experiment to be correct.

STUDENTS of the Batrachians will be much interested to read in the *Proc. U.S. Nat. Mus.* Dr. Stejneger's account of the discovery of a North American representative of the family of disc-tongued frogs (*Discoglossidae*), hitherto supposed to be confined to the northern half of the Old World and New Zealand. The determination rests on a single specimen discovered in the western portion of Washington State, which is considered to belong to a new generic type (*Ascaphus*).

THE July number of the *Century Magazine* contains an exceedingly well-written and well-illustrated article describing a rocky islet in the Gulf of St. Lawrence known as "Bird Rock," and now utilised as a lighthouse station. From the accounts of early visitors to the rock (among whom was Audubon) it appears that the number of sea-birds—such as gannets, guillemots, puffins, razorbills and petrels, with which it was covered—was almost incredible, Dr. Bryant, who paid a visit in 1860, estimating the number of gannets alone at one hundred and fifty thousand. Although, to one who has not read the old accounts, the rock would even at the present day appear a marvellous example of the exuberance of bird-life, it is only too certain that unchecked plunder of the eggs and destruction of the adults are steadily tending towards the extermination of the feathered hosts. By all means, therefore, let the Government concerned forthwith take the simple steps suggested by the author as essential to ward off the occurrence of such a dire calamity.

THE useful series of "Manchester Museum Handbooks" has received an important addition in the form of an "Index to the *Systema Naturae* of Linnæus," by Mr. C. D. Sherborn. Needless to say, this work is executed with the thoroughness and care characterising all the efforts of its author. Whether, however, it will "help in bringing about that uniformity of nomenclature which is the great need of zoological science at the present day," the future alone will show. There may also be two opinions as to whether Linnæus, the founder of our nomenclature, "had no more power to alter a name once founded than has any other person."—The "Guide to the Natural History Collections" in the same series is so well written, and contains such a large amount of information in such a very small compass, that it will prove useful to many besides actual visitors to the museum.

SLOWLY but surely is our information as to the former extension of the range of the Saiga antelope of the Volga steppes tending towards completeness. The latest addition to the remains of this animal is a skull from the superficial deposits of Kulm, recently added to the museum at Dantzic. This specimen, which has been identified by Dr. A. Nehring, is the second hitherto obtained in Germany. As our readers may remember, an imperfect skull was dug up a few years ago near Twickenham.

To the last number of the *Proceedings* of the Royal Physical Society of Edinburgh Messrs. W. S. Bruce and W. Eagle Clarke communicate a paper on the mammalia and birds of Franz-Josef Land. That such a desolate region would have but few land mammals was only to be expected, and the Polar bear and Arctic fox are the only two actually met with, although there are reports as to the occurrence of a hare, and the reindeer is represented by accumulations of its antlers, which were probably carried to their present position years ago by ice-floes. On the other hand, the birds number at least two-and-twenty species.

MR. F. TURNER reprints, from the *Proceedings* of the Australasian Association for the Advancement of Science, a paper on the supposed poisonous plants of South Australia.

THE most recent numbers received of the *Biologisches Centralblatt* contain a continuation of Dr. Keller's useful epitome of the results of recent researches in vegetable physiology and biology, as well as several original papers in different departments of zoology and botany.

WE learn, from an article in the *Board of Trade Journal* for June, that the source of the india-rubber exported from Peru through Pará has been determined by M. Hubert, a botanist on the scientific staff of the Museum of Pará, to be a species of *Castilloa*, possibly identical with the *Castilloa elastica* of Central America.

THE *Transactions* of the British Mycological Society for 1897–1898 contain several interesting papers on British Mycology, but some of them are (admittedly) reprints, and, with regard to the others, there is no information as to the date or place where they were read, or even any note of the meetings of the Society. No date even is given to the delivery of the "President's Address." The officers of the Society appear to be a President, an "Acting President," and an Honorary Secretary and Treasurer.

WE have received vol. i. No. 3 o. the Communicaciones del Museo Nacional de Buenos Aires. It contains a paper on the Coleoptera of Tierra del Fuego, and some short articles on botany, geology and nomenclature.

AN important paper, by Dr. Philip P. Calvert, on Odonata from Tepic, Mexico, with supplementary notes on those of Baja, California, has appeared in the *Proceedings* of the California Academy of Sciences (third series, Zoology, vol. i. No. 12). Detailed descriptions are given of many of the species.

THE thirteenth volume (new series) of the *Geographical Journal*, containing the six numbers of the *Journal* issued this year, has just been published. The papers printed in the volume; the record of geographical events and investigations; and the monthly bibliography of current geographical literature, make the volume, like previous ones, essential to the library of the student of geography.

THE second part of the first volume of the *Annals* of the South African Museum has reached us. Among the papers included in it are: a descriptive list of the rodents of South Africa, by Mr. W. L. Sclater; a further contribution to the South African Coleopterous fauna, by Mr. L. Péringuey; the South African species of Peripatidæ in the collection of the South African Museum, by Dr. W. F. Purcell; and a description of a new genus of Perciform fishes from the Cape of Good Hope, by Mr. G. A. Boulenger, F.R.S.

A THIRD edition, considerably enlarged, of "Metal-Plate Work," by Mr. C. T. Millis, has been published by Messrs. E. and F. N. Spon, Ltd. The volume shows how nearly all the patterns required by sheet-metal-workers can be set out on general geometrical principles. The book has proved of great value to pattern-makers since it was first published twelve years ago, and as the system of construction set forth in it is now regarded as the best means of making the practical man familiar with the geometrical principles underlying his work, the volume should be even more widely used in the future than it has been in the past.

THE additions to the Zoological Society's Gardens during the past week include a Common Paradoxure (*Paradoxurus niger*) from Java, presented by Mr. J. Osborne; a Barbary Mouse (*Mus barbarus*) from Barbary, presented by Miss Lyell; a Cormorant (*Phalacrocorax carbo*) from Scotland, presented by Mr. Percy Leigh Pemberton; two Carrion Crows (*Corvus corone*) British, presented by Lieut.-Colonel Vilett Rolleston; a Rock Thrush (*Monticola saxatilis*), European, a Yellow Hangnest (*Cassicus persicus*) from South America, presented by Mr. H. J. Fulljames; twelve African Walking Fish (*Periopthalmus koelreuteri*) from West Africa, presented by Dr. H. O. Forbes; a Brown Mouse Lemur (*Chirogaleus milii*), two Elegant Galidias (*Galidia elegans*) from Madagascar, a Red-bellied Tamarin (*Midas labiatus*) from the Upper Amazons, two Mexican Conures (*Conurus holochlorus*) from Mexico, a Tabuan Parrakeet (*Pyrrhulopsis tabuensis*) from the Fiji Islands, deposited; a Wapiti Deer (*Cervus canadensis*, ♂), a Great Eagle Owl (*Bubo maximus*), bred in the Gardens.

## OUR ASTRONOMICAL COLUMN.

COMET 1899 *a* (SWIFT).—This comet, after passing perihelion, showed such a definite increase of brightness and other evidence of internal action, that its progress was closely watched at several observatories (*Astronomical Journal*, No. 464, vol. xx. pp. 60–61). Prof. E. E. Barnard, observing it on May 20 and several succeeding occasions, with the 40-inch refractor of the Yerkes Observatory, found the head of the comet to be distinctly *double*, the smaller component being *south preceding* with reference to the main body. From successive measures it was found that the position angle was gradually decreasing, while the distance between the two nuclei was increasing from 28″·84 on the 20th to 38″·16 on the 23rd. Though no tail was visible to the eye, a photograph obtained on May 18 showed a slender tail 6° or 8° long.

Prof. C. D. Perrine also secured several observations with the 36-inch Lick refractor, confirming the duplex character of the head of the comet. The two nuclei were estimated to be of the 8·0 and 9·5 magnitude respectively, and neither appeared stellar with power of 270.

The following continued ephemeris is given by Dr. A. Stichtenoth in *Astr. Nach.* (Bd. 149, No. 3574):—

*Ephemeris for 12h. Berlin Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ | Br. |
|---|---|---|---|
| July 6 | 14 16 54 | +17 16·5 | 0·11 |
| 8 | 15 29 | 16 12·6 | |
| 10 | 14 20 | 15 13·0 | 0·08 |
| 12 | 13 26 | 14 17·3 | |
| 14 | 12 43 | 13 24·9 | 0·06 |
| 16 | 12 12 | 12 35·6 | |
| 18 | 11 52 | 11 49·2 | 0·05 |
| 20 | 14 11 40 | +11 5·2 | |

TEMPEL'S COMET 1899 *c* (1873 II.).

*Ephemeris for 12h. Paris Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ ″ | Br. |
|---|---|---|---|
| July 6 | 20 22 29·7 | −11 13 0 | |
| 7 | 23 44·7 | 11 38 27 | 3·008 |
| 8 | 24 59·3 | 12 4 37 | |
| 9 | 26 13·6 | 12 31 29 | |
| 10 | 27 27·5 | 12 59 1 | |
| 11 | 28 41·2 | 13 27 12 | 3·229 |
| 12 | 29 54·5 | 13 55 59 | |
| 13 | 20 31 7·6 | −14 25 22 | |

HOLMES' COMET (1892 III.).—

*Ephemeris for 12h. Greenwich Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ″ | Br. |
|---|---|---|---|
| July 7 | 1 57 53·4 | +25 17 1 | |
| 9 | 2 0 56·9 | 25 51 37 | 0·0386 |
| 11 | 3 58·5 | 26 26 4 | |
| 13 | 6 58·2 | 27 0 21 | |
| 15 | 9 55·9 | 27 34 28 | 0·0398 |
| 17 | 12 51·4 | 28 8 26 | |
| 19 | 15 44·6 | 28 42 14 | |
| 21 | 2 18 35·5 | +29 15 53 | 0·0412 |

MAXIMA OF MIRA.—Mr. A. A. Nijland, of Utrecht, communicates to *Astr. Nach.* (Bd. 149, No. 3576) an account of his observations of Mira during the apparition in 1898. During the period extending from August 9, 1898, to March 5, 1899, sixty-one observations of magnitude were obtained. The light curve being plotted from these gives the time of maximum as October 4, 1898, this being very close to the predicted time given by Chandler in his third catalogue. The following table shows the observed and calculated times of the last three maxima:—

| Observed maximum. | Calculated Chandler III. | Retardation. Days. | Magnitude. | Period. Days. |
|---|---|---|---|---|
| 1897 Jan. 11 | 1896 Dec. 13 | 29 | 3·70 | |
| 1897 Nov. 26 | 1897 Nov. 9 | 17 | 3·24 | 319 |
| 1898 Oct. 4 | 1898 Oct. 6 | −2 | 2·91 | 312 |

THE NEW ALGOL VARIABLE IN CYGNUS.—Harvard College Observatory *Circular* (No. 44) contains the results of a detailed examination of all the Draper memorial plates covering the region of the variable star BD + 45°·3062, discovered by Mdme. Ceraski at Moscow (see NATURE, vol. lx. p. 114). Altogether 195 plates show the star, on 170 of which it is at its full brightness, while 20 show it below its normal magnitude. A full discussion of these plates resulted in the determination of the period of the variable to be

4d. 13h. 45m. 2s.

It is noticeable that the variation in brightness of this star amounts to about three magnitudes, and therefore exceeds that of any Algol star hitherto discovered. Like all other Algol stars, its spectrum is of the first type. A table showing the times of minima for the remainder of the year is included in the *Circular*.

## *THE HOUSING OF THE OFFICES OF THE UNIVERSITY OF LONDON.*

THE history of the negotiations which have taken place between the Government and the Senate of the University of London, relating to the proposal of the Government to provide accommodation for the University in the Imperial Institute building, is contained in the subjoined extracts from the Report of the Special Committee appointed by the University to confer with representatives of the Treasury and of the Imperial Institute upon the matter.

At a meeting of the Senate held on December 7, 1898, a letter from Sir Francis Mowatt to the Vice-Chancellor (Sir Henry Roscoe) was read, stating that it had been suggested to the Cabinet that an arrangement might be possible by which an adequate and dignified home for the University of London could be provided in the Imperial Institute buildings, subject to some extension and internal alterations, if terms could be offered which would be acceptable to the authorities of the Institute.

The terms submitted to the Senate of the University are as follows:—

"The Government will provide adequate and suitable accommodation for the University of London, as constituted by the Act of last Session, in the buildings of the Imperial Institute, such accommodation to include examination rooms and laboratories either in the building itself or in a new building to be erected immediately adjoining it.

"The Government will undertake the entire cost of the upkeep and maintenance of the buildings, including their protection from fire.

"The works necessary for providing the accommodation in the Institute buildings, corresponding to that now enjoyed by the University in Burlington Gardens—and including the new laboratories—will be put in hand at once; and the headquarters and offices of the University, as at present constituted, will be transferred from Burlington Gardens as soon as possible after the new accommodation is ready for their reception.

"The accommodation in the Institute buildings required for the teaching side of the University will be prepared in anticipation of the date at which the provisions of the Act of last Session come into full operation.

"A Committee consisting of representatives of the University, the Treasury, and the First Commissioner of Works, should be appointed forthwith to inquire and report as to the necessary alteration and adaptation of the Institute buildings for the purposes of the University."

After a brief statement of the scope and object of this offer, the discussion upon the proposals was adjourned. There seemed to be some uncertainty in the minds of certain of the Fellows as to the precise terms upon which the proposed joint occupation of the buildings of the Imperial Institute were to be arranged as between the Government on the one hand and the University and the Imperial Institute on the other. It was felt that if a statement could be made upon certain points raised in the discussion such statement would be of signal service in clearing away any misapprehension which might have arisen. The following inquiries were therefore sent to Sir Francis Mowatt, and, with the replies, were read at a meeting of the Senate on February 1:—

"1. Is it to be understood that the Government proposes to take over the whole of the present building of the Imperial Institute for the use of (*a*) the University of London, (*b*) the authorities of the Imperial Institute?

"2. Will the University (in case the proposals are carried out) be the tenants of the Government under identical conditions as to fixity of tenure, maintenance, &c., as heretofore in Burlington Gardens?

"3. Is it understood:

"(*a*) That the University will become possessed for its sole use of so much of the Institute buildings as the Government shall decide, after communication with the University of London, to be sufficient for its present and prospective accommodation?

"(*b*) That the University shall have the first use of such halls, corridors, galleries, as are necessary for carrying on its work of examination?

"(*c*) That all concerts and other entertainments in the Institute are to be abolished?

"(*d*) That a suitable entrance to the University portion of the building will be provided after due communication with the architect?

"(*e*) That all educational work of University character carried on within such portion of the building handed over to the Institute authorities shall be under the direct control of the University?

"(*f*) That proper accommodation will be provided for the University examinations in practical science either in the Imperial Institute buildings or in others to be built outside as may be decided on after further discussion?"

The reply, dated Christmas Day 1898, was as follows:—

"It is not the intention of the Government that any of the three parties should enter on the proposed inquiry with their hands tied. Their sole wish is that the University, the Institute, and the Treasury should meet and discuss whether *any*, and, if any, what arrangement is possible, under which the University could be suitably housed, and under suitable conditions, in the

present Institute buildings. If the result of the discussion is to show that no suitable arrangement is practicable, the University will be in no way prejudiced by having shown its readiness to discuss the project in a friendly spirit. It will be quite open to the Senate to make an express reservation in the above sense a condition of sending its representatives to sit on the Committee.

"The answer to the first and second questions is yes.

"As regards the third, the answers are—

"(*a*) Yes.

"(*b*) I am not sure that I quite understand the meaning of the words 'the first use,' but if the following definition will meet the views of the Senate, I can answer the question in the affirmative, viz. 'Full and exclusive use and control at all times at which the said halls are required for the purposes of examination.'

"The regulations for giving effect to this condition will be drawn up by the Treasury, who will be responsible for seeing that they are carried out.

"(*c*) The representatives of the Institute have assured me that the entertainments and concerts will not again take place, but it will be quite open to the Senate to safeguard themselves by making the discontinuance of such things a condition of their presence on the Committee.

"The answers to (*d*), (*e*) and (*f*) are in the affirmative."

The views of Convocation upon the proposals are contained in the following letter from the Clerk of Convocation to the Registrar, read at the meeting of the Senate :—

"I am directed by the Special Committee of Convocation, appointed to communicate with the Statutory Commission and the Senate, to request you to inform the Senate that the Committee having had their attention directed to the subject of the proposed transference of the University to the Imperial Institute, adopted the following resolution :—

"That, in the opinion of this Committee, the Imperial Institute would furnish an adequate and dignified home for the University, provided that the exclusive and permanent control of the whole or a distinct and sufficient portion, with an adequate entrance, and with security of tenure, be vested in the University."

On the motion of the Vice-Chancellor, seconded by Lord Kimberley, it was then resolved :

"That with reference to the correspondence between the Vice-Chancellor and Sir Francis Mowatt, the Senate do agree to join in the Conference therein mentioned upon the terms generally set forth in the correspondence, and without prejudice to the ultimate action of the Senate, and that accordingly three Fellows be nominated as a Special Committee of the Senate to serve on the Conference, and to report to the Senate the result of the Conference."

The following Fellows were nominated Members of the Special Committee :—The Vice-Chancellor, Lord Kimberley, and Sir Joshua Fitch.

At the next meeting of the Senate, on February 22, further correspondence was presented. It was announced that the Lords Commissioners of Her Majesty's Treasury had selected the undermentioned gentlemen to represent them at the Conference :—

Sir F. Mowatt and Mr. S. E. Spring Rice, both of the Treasury, and Mr. Almeric Fitzroy, Clerk of the Council.

The following Treasury Minute, dated February 16, 1899, was read :—

"The First Lord and the Chancellor of the Exchequer state to the Board that Her Majesty's Government have had under consideration the possibility of an arrangement with the authorities of the Imperial Institute whereby a dignified and suitable home may be provided in the Institute buildings at South Kensington for the University of London, as reconstituted by the Act of last Session. The accommodation would include the sole occupation and control of rooms and offices fully equal in number and dimension to those now in the possession of the Senate at Burlington Gardens ; examination rooms and laboratories either in or immediately adjoining the existing building ; and also such provision as may hereafter be needed for the full extension and development of the University under the statutes and regulations made by the Commissioners appointed by the Act.

"The First Lord and the Chancellor of the Exchequer state that, as the result of negotiations which have taken place between representatives of the University, the Institute and the Treasury, there is reason to hope that an arrangement meeting all the requirements of the several interests is now possible ; and they recommend to the Board that the authorities of the University and the Institute should be invited to nominate representatives, who will consider and report in conference with persons selected by the Treasury—

"I. Whether such an arrangement is in fact practicable.

"II. What is the amount and nature of the accommodation to be transferred.

"III. What alterations or adaptations are necessary to render it in all respects suitable to the needs of the University.

"IV. Under what conditions it should be held from Her Majesty's Government by the Senate.

"The object of the Conference would be expressly limited to furnishing Her Majesty's Government with full information upon the several points indicated above ; and the consent of the several parties to enter the Conference would not pledge them to accept any recommendation which the representatives, or a majority of them, may make.

"My Lords approve the course recommended by the First Lord and the Chancellor of the Exchequer."

The representatives of the Council of the Institute appointed to take part in this Conference were Lord James of Hereford, the Right Hon. Sir Henry Fowler, M.P., and Sir Frederick Abel.

The Conference thus constituted held several meetings at the Treasury and at the Institute, and the Committee paid repeated visits to South Kensington with a view to ascertain the exact extent and capabilities of the building, particularly of that portion of it which it is proposed to assign to the University.

On the first of these occasions the Prince of Wales met the Committee and accompanied the members through the various rooms of the Institute. His Royal Highness evinced much interest in the proposed arrangement, and expressed a strong wish to meet the requirements of the Senate and to facilitate the work and due development of the University.

At a subsequent meeting the representatives of the University were requested to draw up, for the information of their colleagues, a statement showing the nature of the accommodation needed by the University, and also the way in which the eastern portion of the building might be adapted to the use and to the future requirements of the University. In conformity with this wish the Committee prepared a memorandum, which became the basis of discussion at subsequent meetings of the Conference.

Among the points referred to in this document are the future requirements of the University. Upon this subject the representatives of the University remark :

"In considering the proposal to exchange the present building in Burlington Gardens for a portion of that now occupied by the Imperial Institute, it is necessary not only to take into account the means of supplying these serious deficiencies, but also to forecast the probable requirements of the University under its new constitution. The details of that constitution are now being settled by the Statutory Commission appointed under the provisions of the University of London Act of 1898.

"The new statutes will certainly provide for a large extension in the work and usefulness of the University, will invest it with new teaching powers, will bring it into closer relations with the principal colleges and medical schools of the metropolis, and will, without encroaching on the ordinary functions of those institutions, probably do much to encourage the development of post-graduate study and of research, under the direction of the governing body of the University, and in its central building."

With regard to the central portion of the building, the memorandum states :—

"It is evident that joint user of this neutral territory, on the part of the Institute and the University, would be for many reasons inconvenient unless the relations and claims of the two bodies are clearly defined. Otherwise frequent references to the Treasury would become necessary.

"Moreover, it is essential for the credit and for the usefulness of the metropolitan University that it should not be regarded as, in any sense, a department of another institution. It would cause grave disappointment to the Senate and to the Graduates if we were unable to report to them that the Government were sensible of the importance of this consideration, and able to give effect to it.

"It is obviously desirable that the building to be known as the University of London should have a separate entrance."

It was in relation to the neutral territory referred to that the representatives of the University felt it necessary to receive further explanations. It was at first proposed by the authorities of the Institute that a joint permanent Committee should be formed, and that while the University and the Institute respectively should be entitled to have the use of the central hall and the east conference hall on certain occasions to be specified beforehand, the occupation of the rooms on other occasions should be settled by arrangement with this Committee. But grave inconvenience and the possibility of future complications were foreseen in such an arrangement. From the first it had been impressed upon the Treasury that the relations of the University should be with the Government alone, and that any plan which assumed that the University should be either tenants or partners with another institution would certainly be unwelcome to the Senate. The Committee therefore insisted that, in accordance with the letter of Sir Francis Mowatt of Christmas Day 1898, the University should be the tenants of the Government only. As a result the following formal communication, dated May 16, was received by the Vice-Chancellor from Sir Francis Mowatt:—

"With reference to our recent discussions as to the conditions on which the Government is prepared to offer to the University improved and enlarged accommodation in the Imperial Institute building, I am authorised by the Chancellor of the Exchequer to inform you that the original intention of the Government remains unchanged, namely, to take over *all* the present building for the use of (*a*) the University of London, and (*b*) the authorities of the Imperial Institute, and that he has caused notification to this effect to be communicated to the Council of the Institute.

"I am at the same time instructed to forward to you the enclosed memorandum indicating that the University will hold direct from the Government."

The memorandum enclosed was as follows:—

"In any arrangement under which the University is invited to occupy a part of the Institute building, it will be an absolute condition that the University holds directly and solely from the Government and not in any form or degree from the Institute.

"This is true equally of the part to be occupied exclusively by the University and of the part to be occupied alternately by the University and by the Institute under arrangements to be approved by the Treasury."

The exact nature of the arrangements here referred to between the University and the Treasury, with respect to the central portion of the building, the galleries, and the east conference hall, will be fixed from time to time on the understanding that the full and exclusive use of these portions of the building will be secured for the University at all times at which they are required for purposes of examination, for the annual ceremony of the presentation for degrees, and for the meetings of Convocation. The Senate will also afford, as it has been accustomed to do during many years, accommodation to meetings and congresses of a national and international character, as well as for assemblies of graduates or others interested in the promotion of collegiate or advanced education.

Subject, therefore, to any reservation which the Treasury may make as to the use of the central portion of the main building for occasional meetings of the Imperial Institute, the building, with the exception of the west wing, will either belong exclusively to the University or will be at its disposal when required. The main entrance will be used by the University and by the Imperial Institute jointly. An additional University entrance and staircase will give access to the east wing, and will serve for candidates for examination and for other purposes.

The assent of the Council of the Imperial Institute to the Government proposals was notified in a letter dated June 5 from Lord James of Hereford to Sir Francis Mowatt.

With regard to the future appropriation of land adjacent to the building, it is understood that, in view of the probable future requirements of the University, especially in the direction of scientific and literary research and of post-graduate lectures and studies, the University will be entitled to a first claim on any vacant ground which may hereafter prove to be needed. The area thus available is very large.

It is understood that the Government is prepared to undertake the whole cost of the removal of the effects of the University to its new quarters, and that the Chancellor of the Exchequer will include in the estimates for this year a sufficient sum to meet all charges for furnishing the rooms, for adapting them to the purposes of the University, and also for effecting such structural and other changes as may be found necessary in subsequent consultation between the officers of the University and the architect of the Board of Works. At present no change is proposed in the financial arrangement by which the charges of the University for the maintenance and care of the building, the provision of stationery and stores, the salary of the officers, and the expenses of administration are borne by the Treasury, and are provided, so far as they exceed the amount received from candidates in the form of fees, by an annual vote in Parliament.

This arrangement is, however, wholly exceptional, and does not apply to any other University in Great Britain. It undoubtedly relieves the authorities of the University from all financial concern or responsibility. But it cannot be regarded as a permanently satisfactory settlement, or one which is likely to conduce to the repute and independence of the University, or to its due development in the future. It has the obvious and serious result of discouraging endowments and gifts, and of diminishing the interest which the inhabitants of London ought to take in their chief academic institutions. So long as the University is dependent for its maintenance on an annual vote in Parliament, it can hardly be expected to receive much voluntary support. Such generous gifts from private persons or from municipal bodies as have enriched the colleges of the Victoria University, and have recently been promised to the contemplated University of the Midlands, are not likely to be forthcoming in London while the University exists on its present financial basis. But it may well be hoped that under different conditions the University will evoke similar local patriotism to that which has been so conspicuously shown in Manchester, Liverpool, Leeds, Cardiff, Newcastle and Nottingham, and that the citizens of London will become conscious of a new responsibility, and will take a pride in strengthening and enlarging from time to time an institution which ought to serve as a great centre of intellectual life for the whole metropolis.

The Government has throughout this negotiation shown a strong desire to make the best provision in its power to meet the needs of the University and the wishes of the Senate and the Graduates. And, having regard (1) to the fact that the present accommodation is insufficient, and that there are no means of enlarging it upon its present site; (2) to the size and dignity of the Institute building and its capacity for adaptation and expansion; (3) to the fact that no alternative proposal for the housing of the University in a more appropriate place is likely to be made; and (4) to the consideration that the building, though not geographically central for London, is placed in the midst of a group of institutions—the Royal College of Science, the Natural History Museum, the City and Guilds of London Institute, the College of Music, and the Science and Art Galleries and Museums—which are all in various ways cognate in their objects with the purposes and work of the University, the Committee conclude by expressing the opinion that the proposal of the Government has been conceived in a fair and liberal spirit, and that it deserves the favourable consideration of the Senate.

## *PHYSICAL MEASUREMENTS IN ANTHROPOLOGY.*

THE question of the value of physical measurements is one that lies at the base of physical anthropology. Large numbers of often very extended series of measurements are continually being published, new methods are constantly being proposed and tried; but in spite of all this, it is questionable whether the value of the results obtained is proportionate to the trouble expended. Unfortunately there is variability in the methods employed, which may change according to the nationality of the investigators; some methods are complicated like those of Benedikt and Tœrœk, or, as in the case of the latter anthropologist, who takes 5000 measurements on a single skull, they may be impracticably numerous. Very precise measurement with refined instruments gives an apparent exactitude which appears to be more scientific than it really is. Preferable is the system that adopts a small number of measurements which can be readily made, and which have a better chance of being taken on a large number of subjects. The

extreme exactitude of cranial measurements, especially when based, for example, on the cephalic index only, has often led to creating imaginary races among a given people.

These and other wholesome warnings are uttered by O. Hovorka Edler von Zderas in the *Centralblatt für Anthropologie*, iii. p. 289, who also points out that there is no need to calculate indices to the first or second decimal, and he also states that in the analysis of a people one should not take account of differences of less than ten units in the index.

As all investigators are well aware, the cephalic index gives no information upon the real form of the skull; this has been well emphasised by Sergi, who has sought to establish a more rational system of skull nomenclature. M. L. Laloy supports (*l'Anthropologie*, x. p. 105) Hovorka's general contention, and refers to the clever visual analysis of the inhabitants of Bretagne by Dr. P. Topinard, which was published in the *Journal of the Anthropological Institute* (1897, xxviii. p. 99). In the last number of the *Journal* (new series, i. p. 329) Dr. Topinard gives the results of the trip which he made to Cornwall last year in order to compare the anthropological types there with those he had previously ascertained in Bretagne. But in our own country Dr. J. Beddoe has long adopted a similar method of investigation, and his acute and trained powers of observation have thrown a flood of light on the problems of the races of Britain. The methods of the *doyen* of British anthropologists are those of the field naturalist, and there are many who realise that what is generally known as "natural history," is as integral a part of biology as is the most refined laboratory technique. It is well to use one's eyes for other purposes than for reading off scales on instruments.

## *WAVE OR BILLOW CLOUDS.*

A SERIES of cloud photographs taken by Mr. Alfred J. Henry, of the United States Weather Bureau, and contributed to the *Monthly Weather Review* for February, is on several grounds specially instructive. It is too frequently the case that photographers content themselves with a single plate of a cloudy sky, which specially recommends itself to their notice by the grouping and arrangement of the vaporous patches. But in this instance we have a succession of pictures of the same clouds, showing their variation during the interval, and, moreover, taken in various azimuths at different stations, so that we get the same formation viewed from different standpoints. We regret that we can only reproduce one of the very admirable pictures that Prof. Henry has secured, It is the first of the series, and shows the typical arrangement of these clouds as they first arrested the attention of the observer. The altitude was probably that of the mean altocumulus level. Occurring as these clouds do at all possible heights above the surface, we are glad to notice that the term wave or billow, following the nomenclature of Helmholtz, is coming into use, since such a description more nearly expresses the character of the formation than do other terms which generally refer to the height alone.

We have here in the cause of the formation of these clouds an instance of the advantage of theoretical investigation over simple observation. The readings of meteorological instruments explain nothing of the origin or behaviour of atmospheric waves. Prof. Henry has recorded for us, with the care that becomes a meteorologist, that the wind was blowing steadily from the north-west with a velocity of twelve miles an hour. Rain had ceased shortly before, and the temperature, which had fallen to 34° during the night, had risen at the time at which the photograph was taken (8h. 25m. a.m.) to 36°. The direction of the parallel bands when first observed was approximately east and west. Later they took up a position about N. 80° W. to S. 80° E. In an hour and a half the typical appearance of the billow wave had passed away, leaving the sky about half covered with cirrus and cirro stratus. It is not unimportant to note, however, that the occurrence of similar weather conditions gave rise to a similar formation of clouds (also photographed) some two months later.

This is all that instrumental registration and careful observation can teach us, and possibly the slow onward movement of meteorological science is traceable to the strict adherence we have generally shown to the record of instrumental indications, rather than a confident appeal to theoretical research. But the study of such a cloud formation as that pictured here goes a step beyond the reading of instruments, and places in our hands a powerful means by which to investigate the motion of the atmosphere. It cannot have escaped general notice that this regular arrangement of streaks presents the peculiarity of covering a considerable extent of the sky, almost simultaneously. On a comparatively clear sky these strips of cloud are suddenly formed; and on the other hand, a sky uniformly covered can, in a very short space of time, break up and offer the appearance of these billow waves. This sudden origin of parallel streaks finds a complete analogy in the formation of waves over still water, when a slight wind agitates the surface, and it is seen to break into ripples over a considerable area. Von Helmholtz, working on this suggestion, has shown conclusively that these billow waves are due to the existence of air strata of different temperatures moving with different velocities, and are produced at the surfaces of separation of these various strata. Travellers in balloons have confirmed this theory from actual experiment, and have shown that at very various altitudes this peculiar formation is encountered. It may be that the billow clouds are visible to us only under peculiar circumstances of moisture, but the wave motion in the invisible air is probably a most common phenomenon, and one that plays a large part in determining our weather conditions.

Wave or Billow Clouds.

## *THE PROPOSED MAGNETIC SURVEY OF THE UNITED STATES.*[1]

THE present superintendent of the Coast and Geodetic Survey, Prof. Henry S. Pritchett, perceiving the need of expansion in the magnetic work of the Survey, has brought about the formation of a separate division, known as the Division of Terrestrial Magnetism of the United States Coast and Geodetic Survey. The chief of this division is to be Dr. L. A. Bauer, who will have full control of all magnetic work, both in the field and in the office.

The following preliminary outline will serve to give some indication of the character and scope of the work it is proposed to carry out with the enlarged opportunities.

### Secular Variation Investigations.

The best evidence of the great demand for secular variation data is the fact that, thus far, eight editions of Schott's secular variation paper have been successively issued by the Survey.

[1] Abridged from an advance proof of a paper by Dr. L. A. Bauer in *Terrestrial Magnetism*.

In all matters relating to the re-location of land boundaries, where it is frequently necessary to know the precise amount of angular change in the direction of the magnetic meridian since the first or original survey, the Coast and Geodetic Survey is recognised throughout the country as the ultimate authority. The amount of money saved to landowners by such authoritative determinations as the Survey is able to furnish, can scarcely be estimated. It certainly exceeds many times the total amount to be spent for magnetic work.

Every effort will be made in the future to multiply and verify the secular variation data, and requests for information on the part of surveyors will be encouraged in every possible manner and true meridian lines established for them.

This involves the determination of the magnetic elements, declination, dip, and intensity at various points throughout the land. Exactly how close the stations shall be to each other depends upon the special purpose to be accomplished with the means at hand, and the magnetic character of the regions involved.

A magnetic survey has peculiar difficulties to contend with; for the quantities to be experimentally determined are for ever undergoing changes—some periodic, others not periodic. A magnetic survey must, therefore, be made to refer to some particular moment of time, and such means must be taken as to enable one to reduce all the measurements, not only to the selected epoch of the survey, but also, as occasion may demand, to some other epoch in the near past or in the near future. Means must also be taken for the proper elimination of all such errors as are to be referred entirely to the particular magnetic instrument used, *i.e.* instrumental errors.

### NUMBER AND DISTRIBUTION OF STATIONS.

At how many stations it will be necessary to determine the magnetic elements? The areas of the countries at present belonging to the United States are, approximately, as follows:—

| | | |
|---|---|---|
| United States ... ... ... | 3,025,600 | square miles |
| Alaska ... ... ... ... ... ... | 577,390 | ,, |
| Hawaiian Islands ... ... ... | 6,250 | ,, |
| Porto Rico ... ... ... ... ... | 3,530 | ,, |
| Total ... ... ... | 3,612,770 | ,, |

Hence the area is equal to that of entire Europe, or about one-fifteenth of the entire land area of the globe. As magnetic surveys have been especially prosecuted in Europe, it will be of interest to note the density of distribution of the magnetic stations in two recent, fruitful magnetic surveys—viz. that of Great Britain, where there was one station to every 139 square miles; and that of Holland, embracing one station to every 40 square miles.

Suppose one station is decided upon, on the average, to every 100 square miles—an end that may be obtained some day—then the determination of the magnetic elements would be required at 30,000 stations within the United States. At the rate of 400 stations a year, the magnetic survey, as detailed as this, would require for its completion at least seventy-five years. It is not well, however, to have a magnetic survey extend over such a long interval of years. The errors incurred in reducing the observations to a common epoch would greatly exceed the errors of observation.

It is evident, then, that a very large number of observers and instruments would be required to complete the survey within a short interval, say ten years at the most, or a less detailed survey will have to be undertaken.

The plan of conducting a magnetic survey of the United States which appears to be best suited to the present conditions, and one that it is possible to carry out within a reasonably short time, is as follows:—To make first a general magnetic survey of the country with stations about twenty-five to thirty miles apart; then, as opportunities present themselves, to add stations in the magnetically disturbed areas. The observations at the "repeat stations," made from time to time, will furnish the proper secular variation corrections.

The great advantages of this plan over that of attempting a greatly detailed magnetic survey at once, the steady progress of which over the entire country, on account of its extent, would necessarily be very slow, will be readily perceived. It will be of interest, however, to point out that the plan, as briefly outlined, will make it possible, within a reasonable time, to construct two sets of magnetic maps for the same epoch, each set based upon a different distribution of the stations. An opportunity will thus be afforded, as in the case of the magnetic survey of Great Britain, to obtain some idea of the accuracy with which the isomagnetic lines can be determined. The satisfactory solution of this question will serve as a valuable guide in future magnetic work.

Various State geologists, incited by the example set by the State Geologist of Maryland, Prof. William Bullock Clark, either have already made plans, or are making plans, for detailed magnetic surveys of their respective States, in co-operation with the Coast and Geodetic Survey.

### MAGNETIC SURVEY OF OCEAN AREAS.

Provision for the determination of the magnetic elements at sea are being made. With the many vessels at the service of the Coast and Geodetic Survey, exceptional facilities for this purpose will be afforded. In fact, one of the chief duties of the Survey is the supplying of magnetic data to the mariner. From an economic standpoint this feature of magnetic work is the one really of the greatest practical importance. In recognition of this fact, the Survey vessels will hereafter take advantage of every opportunity to obtain the magnetic elements on sea and on shore.

### MAGNETIC OBSERVATORIES.

The rapid, successful, and economical execution of the plans as above briefly outlined requires the establishment, at certain points, of magnetic observatories, where the countless variations in the earth's magnetic force are continuously and automatically recorded, enabling thus the proper corrections to be applied to observations made at stations at any hour of the day.

The present plans contemplate the establishment of a magnetic observatory near Washington City—this will be the Central or Standard Observatory; another near Seattle, State of Washington; one in the Hawaiian Islands, and one in Alaska. With the co-operation of the observatories at Toronto, Mexico and Havana, and with the aid of secondary or temporary observatories established as occasion may demand, the areas to be surveyed will be fairly well covered.

It is very much to be hoped, however, that the universities and colleges in the United States will seriously consider the establishment of magnetic observatories. Many an institution which lacks the means of making a reputation in astronomical work, could still afford to inaugurate useful work in terrestrial magnetism.

The United States stands at the bottom of the list of civilised countries possessing magnetic observatories. Almost every European Power of note maintains, not only one, but several permanent magnetic observatories. France has four already established, and four additional ones in process of erection; and progressive Japan, with its small strip of territory, has six continuously operating magnetic observatories.

The recent International Magnetic Conference recommended the establishment of a magnetic observatory at the Lick Observatory. It is earnestly to be hoped that this suggestion will be carried out. It is unfortunate that the San Antonio observatory in Texas had to be abandoned. A permanent observatory should be re-established in this locality.

The scheme of work for the Coast and Geodetic Survey observatories will embrace, in addition to the regular magnetic work, observations in atmospheric electricity and of the electric currents within the earth. Such observations can be carried on with practically no additional cost, and yet add greatly to the value of the observatory work. Arrangements will likewise be entered into with the Potsdam Magnetic Observatory for the making of strictly simultaneous observations of a special character.

The plan of referring the initiation and prosecution of magnetic work in America to such a well-organised department as the Coast and Geodetic Survey, the work of which is recognised universally as of the highest order, will readily be seen to have decided advantages. In the first place, the machinery for carrying on the work is already to a great extent in existence. The observer engaged in geodetic or astronomical work can frequently include to advantage magnetic observations, and thus can often be saved the chief cost of magnetic work—the occupying of stations. Again, the care and refinement with which the geodetic and astronomical work of this bureau is carried out will ever be an incentive to keep the magnetic work of the same high order.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The following is an extract from the speech delivered at the Encaenia on the presentation of F. D. Godman, F.R.S., Trustee of the British Museum, for the degree of D.C.L., June 21.

"In ea Naturae parte quae ad animalium herbarumque varietates pernoscendas spectat neminem vel diligentius vel utilius hoc viro laborasse scitote.

Ille enim, scientiae amore instigatus, Americae quae dicitur centralis saltus silvasque una cum amico suo caro Osberto Salwino (nuper fato eheu! nobis abrepto) longis pererravit peregrinationibus atque fruges fetusque omnes ejus orbis terrarum partis adcurate investigavit.

Nec illud tacendum arbitror eundem diversi generis species illic ab ipso cura infinita collectas quum rarissimas tum etiam pretiosissimas singulari munificentia Museo nostro Britannico donasse."

THE Committee of the City and Guilds of London Institute are inviting applications for the appointment of Assistant Professor in the Department of Civil and Mechanical Engineering at the Institute's Central Technical College. Particulars of the appointment may be had of the Honorary Secretary of the Institute, Gresham College, E.C.

THE Board of Education Bill was considered by the House of Commons Committee of Ways and Means on Tuesday. It was resolved "That it is expedient to authorise the payment, out of moneys to be provided by Parliament, of a salary, not exceeding 2000*l.*, to the president of the Board of Education, and of salaries and remuneration to the secretaries, officers, and servants of the Board, in pursuance of any Act of the present Session to provide for the establishment of a Board of Education for England and Wales."

MAJOR-GENERAL SIR JOHN F. D. DONNELLY, K.C.B., retired on Monday from the Secretaryship of the Science and Art Department, after forty years in the public service. In consequence of Sir J. Donnelly's retirement, the Duke of Devonshire, Lord President of the Council, has made the following appointments:—Sir George W. Kekewich, K.C.B., the present Secretary of the Education Department, to be also Secretary of the Science and Art Department. Captain W. de W. Abney, C.B., to be the Principal Assistant Secretary of the Science and Art Department. Mr. W Tucker, C.B., to be the Principal Assistant Secretary of the Education Department.

THE Duke and Duchess of York visited Exeter on Tuesday and opened a new wing of the Albert Memorial Museum and College. The Museum became affiliated with the Cambridge University several years ago, when the Exeter Technical and University Extension College was started, with Mr. A. W. Clayden as principal. This institution, to be known in future as the Royal Albert Memorial Museum and College, is now sufficiently equipped for the requirements of a local college. In opening the new wing, the Duke of York remarked that the efficient results attained at Exeter and also at Reading seem to indicate that it is possible for the municipal authorities of towns of moderate size to establish, with the co-operation of the great universities, institutions providing for higher and technical instruction. The co-operation of the universities, with their expert knowledge, and the local authorities with their control of funds for educational purposes and their practical knowledge of local needs, cannot fail to be of the greatest advantage to the community from an educational standpoint.

## SCIENTIFIC SERIALS.

*Meteorologische Zeitschrift*, June.—On the amount of cloud in Europe during cyclonic and anticyclonic days, by Dr. C. Kassner. In this important discussion the author has investigated the cloud observations at five principal stations in Europe for twenty years (1871-90), and has followed a plan adopted by Dr. Leyst in another discussion by selecting the days in each month when the readings of the barometer were lowest or highest. These days, including the days preceding and following that on which the extreme reading occurred, are those called respectively cyclonic or anticyclonic periods. He finds that in cyclonic periods the maximum amount of cloud only occurs on the principal day in summer and autumn, while in winter and spring a large amount of cloud occurs in the evening of the preceding day as well as on the morning of the principal day. The preceding day has generally somewhat less cloud than the principal day, and almost always more than the following day. This result agrees with that deduced by the late Mr. Ley, and by the Deutsche Seewarte with respect to the distribution of cloud in cyclones. In anticyclonic periods the least cloud frequently occurs, not on the principal day, but on the preceding or following day; this is especially the case at Christiania and Pavlovsk, where the least cloud occurs before the passage of the highest barometric pressure, and then gradually increases. Generally speaking, however, the principal day is clearest, and next to this the preceding day, but not always, for at Buda-Pesth and Tiflis the day following that of the maximum barometric pressure has less cloud than the day preceding.

*Bollettino della Società Sismologica Italiana*, vol. iv., 1898, No. 9.—Old seismic instruments, by P. Tacchini, referring to an old form of the Cecchi seismograph and to Cacciatore's mercury seismoscope, recently acquired by the Central Office of Meteorology and Geodynamics at Rome, and which, with others already in the possession of the office, will form the nucleus of a seismometrical museum.—Principal eruptive phenomena in Sicily and the adjacent islands during the half-year July to December 1898, by S. Arcidiacono.—Later modifications in the electrical seismoscope of double effect, by G. Agamennone. Describes several improvements by which the instrument may be put more rapidly in working order.—Notices of earthquakes recorded in Italy (December 25 to 31, 1897), by G. Agamennone, the most important being an after-shock of the Umbria-Marches earthquake of December 27, and the Haiti earthquake of December 29.

## SOCIETIES AND ACADEMIES.

### LONDON.

**Royal Society**, June 15.—"The Colour Sensations in Terms of Luminosity." By Captain W. de W. Abney, C.B., D.C.L., F.R.S.

This paper deals with a determination of the colour sensations (based on the Young theory) by measuring the luminosity of the three different colour components in a mixed light which matches white. At the red end of the spectrum there is but one colour extending from its extreme limit to near C, and there is no mixture of other colours which will match it, however selected, and is, on the theory adopted, a colour which excites but one sensation. At the violet end of the spectrum, from the extreme violet to near G, the same homogeneity of light exists, but it is apparently due to the stimulation of two sensations, a red and a blue sensation, the latter never being stimulated alone by any spectrum colour. Having ascertained this, it remained to find that place in the spectrum where the blue sensation was to be found unmixed with any other sensation except white. By trial it was found that close to the blue lithium line this was the case, and that a mixture of this colour and pure red sensation gave the violet of the spectrum when the latter was mixed with a certain quantity of white. The red and the blue sensation being located, it remained to find the green sensation. The complementary colour to the red in the spectrum gave a position in which the green and blue sensations were present in the right proportions to make white, and a point nearer the red gave a point in which the red and blue sensations were present in such proportions as found in white, but there was an excess of green sensation. By preliminary trials this point was found. The position in the spectrum where the yellow colour complementary to the violet was also found. The colour of bichromate of potash was matched by using a pure red and the last-named green. To make the match, white had to be added to the bichromate colour. A certain small percentage of white was found to exist in the light transmitted through a bichromate solution with which the match was made, and this percentage and the added white being deducted from the green used, gave the luminosity of the pure green sensation existing in the spectrum colour which matched the bichromate. Knowing the percentage composition in luminosity of the two sensations at this point, the luminosity of the three sensations in white was determined by

matching the bichromate colour with the yellow (complementary to the violet) and the pure red colour sensation. From this equation and from the sensation equation of the bichromate colour already found, the sensation composition of the yellow was determined. By matching white with a mixture of the yellow and the violet, the sensation equation to white was determined. The other colours of the spectrum were then used in forming white, and from their luminosity equations their percentage composition in sensations were calculated. The percentage curves are shown. The results so obtained were applied to various spectrum luminosity curves, and the sensation curves obtained. The areas of these curves were found, and the ordinates of the green and violet curves increased, so that both their areas were respectively equal to that of the red. This gave three new curves in which the sensations to form white were shown by equal ordinates.

A comparison of the points in the spectrum where the curves cut one another, and of those found by the red and green blind as matching white, show that the two sets are identical, as they should be. The curves of Koenig, drawn on the same supposition, are mentioned, and the difference between his and the new determination pointed out.

The red below the red lithium line, as already pointed out, excites but one (the red) sensation, whilst the green sensation is felt in greatest purity at $\lambda$ 5140, and the blue at $\lambda$ 4580, as at these points they are mixed only with the sensation of white, the white being of that whiteness which is seen outside the colour fields.

"A Comparison of Platinum and Gas Thermometers, including a Determination of the Boiling Point of Sulphur on the Nitrogen Scale: an Account of Experiments made in the Laboratory of the Bureau International des Poids et Mesures, at Sèvres." By Drs. J. A. Harker and P. Chappuis. Communicated by the Kew Observatory Committee.

The present paper is the outcome of the co-operation of the Kew Observatory Committee and the authorities of the International Bureau of Weights and Measures at Sèvres, for the purpose of carrying out a comparison of some platinum thermometers with the recognised international standards.

A new resistance-box, designed for the work, and special platinum thermometers together with the other accessories needed were constructed for the Kew Committee, and, after their working had been tested at Kew, were set up at the laboratory at Sèvres in August 1897. The comparisons executed between these instruments and the standards of the Bureau may be divided into several groups. The first group of experiments covers the range $-23^\circ$ to $80^\circ$, and consists of direct comparisons between each platinum thermometer and the primary mercury standards of the Bureau. Above $80^\circ$ the mercury thermometers were replaced by a gas-thermometer, constructed for measurements up to high temperatures. The comparisons between $80^\circ$ and $200^\circ$ were made in a vertical bath of stirred oil, heated by different liquids boiling under varying pressures. For work above $200^\circ$ a bath of mixed nitrates of potash and soda was substituted for the oil tank. In this bath comparisons of the two principal platinum thermometers with the gas-thermometer were made up to $460^\circ$; and with a third thermometer, which was provided with a porcelain tube, we were able to go up to $590^\circ$. Comparisons of the platinum and gas-scales were carried out at over 150 different points, each comparison consisting of either ten or twenty readings of the different instruments.

By the intermediary of the platinum thermometers a determination of the boiling point of sulphur on the nitrogen scale was also made. The mean of three very concordant sets of determinations with the different thermometers gave $445^\circ \cdot 27$ as the boiling point on the scale of the constant volume nitrogen thermometer, a value differing only about $0^\circ \cdot 7$ from that found by Callendar and Griffiths for the same temperature expressed on the constant pressure air scale.

If for the reduction of the platinum temperatures in our comparisons we adopt the parabolic formula proposed by Callendar, and the value of $\delta$ obtained by assuming our new number for the sulphur-point, we find that below $100^\circ$ the differences between the observed values on the nitrogen scale and those deduced from the platinum thermometer are exceedingly small, and that even at the highest temperatures the differences only amount to a few tenths of a degree.

Full details as to the instruments employed and the methods adopted are given in the paper.

"On the Comparative Efficieny as Condensation Nuclei of positively and negatively charged Ions." By C. T. R. Wilson, M.A. Communicated by the Meteorological Council.

When moist air is ionised, a greater degree of supersaturation is required to cause water to condense on the positively charged ions than on the negatively charged ones. The experiments consisted in measurements of the expansion required to cause condensation in the form of drops in air initially saturated and containing ions alternately nearly all positive and nearly all negative The ratio of the final to the initial volume being indicated by $v_2/v_1$, then to cause water to condense on negatively charged ions, the supersaturation must reach the limit corresponding to the expansion $v_2/v_1 = 1 \cdot 25$ (approximately a fourfold supersaturation). To make water condense on positively charged ions, the supersaturation must reach the much higher limit corresponding to the expansion $v_2/v_1 = 1 \cdot 31$ (the supersaturation being then nearly sixfold). Thus, if ions ever act on condensation nuclei in the atmosphere, it must be mainly or solely the negative ones which do so, and thus a preponderance of negative electricity will be carried down by precipitation to the earth's surface. Experiments were carried out which appear to prove that the difference in the condensing power of positive and negative ions is not to be explained by supposing the charge of each negative ion to be, for example, twice as great as that of each positive ion. Experiments were also tried to test whether the rainlike condensation, which always takes place in moist air when the expansion $v_2/v_1 = 1 \cdot 25$ is exceeded, is due to slight ionisation of the moist air. These experiments led to the conclusion that this is not a case of condensation on ions; unless the process of producing the supersaturation itself gives rise to ionisation.

**Mineralogical Society**, June 20.—Prof. A. H. Church, F.R.S., President, in the chair.—Mr. E. G. J. Hartley gave the results of analyses of so-called plumbogummite from Roughten Gill, Georgia, and Huelgoat. The blue mineral from Roughten Gill, usually regarded as a silicate or carbonate of zinc, proved to be identical with the hitchcockite from Georgia. Both minerals have been analysed by Mr. Hartley, and shown to contain about 19 per cent. of water and 3 per cent. of carbonic acid. In a note on the optical characters, Prof. Miers finds that these two minerals present absolutely the same appearance under the microscope, and differ somewhat from the only other known hydrated lead aluminium phosphate, viz. the plumbogummite from Huelgoat in Brittany. Mr. Hartley's analyses of this mineral differ from those of Damour, and shows that it has by no means the same composition as hitchcockite, and it is therefore considered to be a distinct species.—Mr. H. L. Bowman gave a detailed description of the optical crystallographic and chemical characters of a clear green rhombic pyroxene from the diamond-washings of South Africa.—Messrs. G. T. Prior and L. J. Spencer contributed a paper on the chemical composition of tetrahedrite. In a previous investigation proving the specific identity of the rare mineral binnite with tennantite, the numbers obtained in the analysis, like those of several older analyses of tennantite, agreed much more closely with the formula $3Cu_2S.As_2S_3$ than with the ordinary text-book formula $4Cu_2S.As_2S_3$, originally proposed by Rose. In the present communication the authors describe the physical and chemical characters of three specimens of tetrahedrite. The result of the analyses made by Mr. Prior is to confirm the idea that the true formula for tetrahedrite proper is $3Cu_2S.Sb_2S_3$, and also to show that when iron and zinc are present they enter into the composition of the crystals not as $3(Fe,Zn)S.Sb_2S_3$, but as $6(Fe,Zn)S.Sb_2S_3$, in which $6(Fe,Zn)S$ isomorphously replaces $3Cu_2S$. The proposed general formula for fahlerz (tetrahedrite and tennantite) is accordingly

$$3R'_2S.R'''_2S_3 + x[6R''S.R'''_2S_3]$$

where $R' = Cu, Ag$; $R''' = Sb, As, Bi$; $R'' = Fe, Zn$, and $x$ is generally a small fraction, rising, however, to $\frac{1}{2}$ in the case of the highly ferriferous tetrahedrite "coppite."—Mr. L. Fletcher described the chemical analysis of a constituent of the meteoric iron of Youndegin, Western Australia, and gave an account of the fall of meteoric stones at Mount Zomba, British Central Africa, on January 25, 1899.—Mr. Herbert Smith pointed out the specific identity of the new oxychloride of lead paralaurionite, described by him in April 1898, with the new mineral rafaelite, a description of which by the late Dr. Arzruni has just been published.

**Geological Society**, June 21.—W. Whitaker, F.R.S., President, in the chair.—On a series of agglomerates, ashes, and tuffs in the Carboniferous Limestone series of Congleton Edge, by Walcot Gibson and Dr. Wheelton Hind. With an appendix on the petrography of the igneous rocks, by H. H. Arnold-Bemrose. After referring to the discovery of volcanic rocks in the upper part of the Carboniferous Limestone series at Tissington, the authors proceed to describe evidence of volcanic action of the same age on the western slopes of Congleton Edge.—On some ironstone fossil nodules of the Lias, by E. A. Walford.—Additional notes on the glacial phenomena of Spitsbergen, by E. J. Garwood. This paper contains the results of additional observations on the ice of Spitsbergen made by the writer in 1897. The inland ice visited occupies two distinct areas, separated by Dickson's Bay and Wijde Bay. The radiating point lies somewhat north-west of the centres of each area, with supplementary radiating points on the north and east. The group of peaks including the Three Crowns may be regarded as nunatakkr. The valley-bound ground-ice does not necessarily travel in the same direction as that of the surface. The effect of nunatakkr on the surface of the ice-sheet was studied, and from this it was often found possible to infer the existence and position of buried mountain-ridges. On the *stoss-seite* of a nunatak moraine-material is often discharged. The movement of the ice has frequently converted the ice-bridges across crevasses into arches and tunnels, some of which carry part of the drainage of the ice-sheet. Portions of old stranded ground-moraines, formed when the ice was more extensive, were sometimes found to have fallen upon the lowered ice-sheet, and to be mingled with modern moraine-material. Englacial and superficial rivers are described, and one of the latter was found to be depositing gravelly material along a line at right angles to the valley down which the ice was flowing. Certain observations on the rate of movement of the ice-sheet seem to indicate that this is not less than fifteen to twenty feet in twenty-four hours; while the glaciers near the sea-margin appear to be travelling about twenty-five feet in the same time. The action of sea-ice is described, and it is inferred that a certain amount of rounding and scratching of shore-rocks, and possibly part of the smoothing of boulders, may be due to this agent.—Additional notes on the vertebrate fauna of the rock-fissure at Ightham (Kent), by E. T. Newton, F.R.S.

**Royal Microscopical Society**, June 21.—Mr. E. M. Nelson, President, in the chair.—The President exhibited an old ⅛-inch objective made by Andrew Ross, which had been presented to the Society by the Master of the Rolls. It was a rare form of objective, constructed probably about the year 1838, and possessed a very primitive form of adjustment. A special interest was attached to it because it formerly belonged to the father of the donor, Prof. John Lindley, the second President of the Society (1842–43).—The President also exhibited a new coarse adjustment which Messrs. Watson had made in accordance with a suggestion contained in his paper read before the Society in March last. It showed that with a loose pinion it was possible to have a rack coarse adjustment that would work without "loss of time."—A paper by Mr. Jas. Yate Johnson, entitled "Notes on some sponges belonging to the Clionidæ obtained at Madeira," was taken as read. Six slides of Spiculæ, &c., in illustration of the paper, were exhibited under microscopes.—The President called the attention of the Fellows present to an exhibition by Mr. Beck of parts of various wild flowers shown with low powers.—This was the last meeting of the session, and the President announced that the first meeting after the vacation would be on October 18.

EDINBURGH.

**Royal Society**, June 5.—Sir Arthur Mitchell in the chair.—A note by Dr. Thomas Muir, on a persymmetric eliminant, was taken as read.—Dr. A. T. Masterman read a paper on contributions to the life-histories of the cod and the whiting. The paper was illustrated by numerous diagrams tracing the successive stages of development from lengths of 3 mm. to lengths of 25 mm. There was found to be a greater abundance of pigment in young whiting, and the body shows a characteristic pigmented lateral line. The migration of the young of each species shorewards was also studied. In the case of the cod the transition was very marked from surface to mid-water, and thence to the littoral region. Thus the limiting length of surface forms was 17 mm., of mid-water forms a little over 25 mm., and later forms were all found in the littoral regions. No attempt has as yet been made to trace outward migration, if there be any. As had already been pointed out by Prof. McIntosh, the migration of the whiting was much more indefinite. Sufficient causes for these migrations had not yet been satisfactorily made out.—Dr. Hugh Marshall gave a preliminary note on the hydrolysis of thallic sulphate.

June 19.—Sir William Turner, F.R.S., in the chair.—A paper by Dr. Thomas Muir, on the eliminant of a set of general ternary quadrics, was taken as read.—Messrs. A. C. Seward, F.R.S., and A. W. Hill presented a paper on the structure and affinities of a Lepidodendron stem from the Calciferous Sandstone of Dalmeny. The fossil stem described in this paper was found by Mr. J. Kerr, of Edinburgh, and generously handed over by Mr. Robert Kidston, of Stirling, to Mr. Seward for examination and description. The peripheral portion of the stem is occupied by a band of secondary cortical tissue (phelloderm) about 5-7 cm. in breadth; the more internal cortex has not been preserved, but the central cylinder is unusually perfect. The specimen measures 33 cm. in diameter. A fairly broad pith occupies the centre of the stem, and this is enclosed by a ring of primary xylem succeeded by a broad band of secondary xylem. The leaf traces exhibit a well-marked secondary growth; each consists of a few primary tracheids, accompanied by a fan-shaped group of short and thin-walled tracheal elements. The stem appears to be identical with *Lepidophloios Wunschianus* from Arran, and a comparison is also instituted with *Lepidophloios Harcourtii*, a species characterised by the absence or late development of secondary wood.—Dr. T. H. Bryce read a paper on duplicitas anterior in an early chick embryo. This very rare condition in birds was examined in careful detail, and the structure of the duplex embryo was demonstrated by microphotographs of typical section.—In a paper on the trap-dykes of the Orkneys, Mr. J. S. Flett gave a description of a series of trap-dykes running mostly in an east-north-east direction, and cutting the Old Red Sandstone of Orkney. They are principally camptonites, but include also bostonites, monchiquites, fourchites, alnoites, and mellilite monchiquites. They are remarkably fresh, and show an interesting series of gradations between the different types. They are probably of Tertiary age, and have all proceeded from one focus. The presence of a single diabase dyke points to their origin from a gabbro magma.—Miss E. Chick presented a paper on the vascular system of the hypocotyl and embryo of *Ricinus communis*, which contained a detailed study of the behaviour of the vascular system in its passage from the root to the stem. Certain anomalies which have been observed were explained, and the inquiry brought out very clearly the individuality of the bundles as compared with the whole central cylinder of the root to which they belong.—Dr. W. Peddie, in a note on Mr. J. O. Thompson's paper on torsional oscillations (see NATURE, May 25, p. 86), pointed out that Mr. Thompson's suggested explanation of the results described by Lord Kelvin is very improbable, for there is no apparent reason why too large an initial oscillation should be given always to the fatigued wire and not to the unfatigued wire. Experiments on an iron wire, already described by Dr. Peddie, showed distinct fatigue of elasticity. It was also pointed out that Mr. Thompson's own results seem themselves to indicate fatigue.

PARIS.

**Academy of Sciences**, June 26.—M. Van Tieghem in the chair.—Note accompanying the presentation of the fourth part of the photographic atlas of the moon, by MM. Loewy and Puiseux. The salient characters of the regions represented are described.—Preparation of fluorine, by electrolysis, in an apparatus of copper, by M. Henri Moissan. The costly platinum apparatus hitherto employed in the preparation of fluorine may, it is found, be replaced by one of copper, which is less attacked than most other metals. It is probable that the copper becomes coated with a thin layer of copper fluoride which, being insoluble in hydrofluoric acid, prevents further action taking place.—Action of some gases on caoutchouc, by M. D'Arsonval. At pressures varying from 1 to 5 atmospheres caoutchouc absorbs large quantities of carbonic anhydride and, at the same time, increases considerably in volume and becomes more gelatinous and less elastic. On exposure to air the gas is gradually lost, and the substance resumes its original properties. In virtue of this property, vessels of caoutchouc readily allow car-

bonic anhydride to pass through their walls. The action is much slower in the case of oxygen and is very slight with nitrogen.—The report of the commission recommending the revision of the map of France was adopted.—Observations on the work of MM. S. Lie and A. Meyer. A mathematical paper.—A new formula relating to quadratic residues, by M. P. Pépin. A paper dealing with the theory of numbers.—On the equation of motion of automobiles, by M. A. Petot. A reply to the criticisms of M. Blondel on a former communication by the author.—On the temperature of maximum density of aqueous solutions of alkali chlorides, by M. L. C. De Coppet. Experiments were made with the chlorides of potassium, sodium, lithium, and rubidium. It is remarkable that the molecular lowering of the point of maximum density caused by lithium chloride is less than half that observed in the case of the other salts examined.—On an oscillation phakometer, by M. Ch. Dévé. The superior accuracy claimed for this instrument for measuring the curvature of optical surfaces, &c., depends on the use of a novel artifice for determining the exact position of an image.—On a laboratory spectroscope in which the dispersion and the scale are adjustable, by M. A. De Gramont.—On the polarisation of dielectrics, by M. Liénard. Observations on a previous note by M. Pellat on this subject.—Results of seismic observations in Greece from 1893 to 1898, by M. D. Eginitis. During the six years over which the observations extended 3187 disturbances were recorded, the average annual number being 531 and the maximum 876 (in 1893). Seismic disturbances are more frequent in the night than in the day, and, as regards their annual distribution, exhibit a maximum in spring and a minimum in autumn.—On the constitution of the oxides of rare metals, by MM. G. Wyrouboff and A Verneuil. Considerations relative to the formation of various complex salts of cerium and thorium lead to the suggestion that the oxides of these metals have the formulæ $(CeO)_3$ and $(ThO)_4$ respectively, in which one of the CeO or ThO groups differs in function from the rest.—The action of ferric chloride and bromide on some aromatic hydrocarbons and on their halogen substitution derivatives, by M. V. Thomas. A continuation of previous work on the subject. From the product of the action of ferric chloride on paradibromobenzene the author has succeeded in isolating two new bromotrichlorobenzenes which melt at 93° and 138° respectively.—The preparation of phenylic chlorocarbonates, by MM. Et. Barral and Albert Morel. The action of a solution of carbonyl chloride in toluene on an aqueous solution of the sodium compound of phenols is shown to afford a ready means of preparing a number of aromatic chlorocarbonates. The temperature at which the reaction takes place should not exceed 40–50°, otherwise decomposition ensues, and the symmetrical phenylic carbonate is produced.—On cerine and friedeline, by MM. C. Istrati and A. Ostrogovich. By fractional dissolution in, and crystallisation from, chloroform, the substance formerly described by one of the authors as extracted from cork has been separated into two distinct compounds, cerine, $C_{27}H_{44}O_2$, and friedeline, $C_{43}H_{70}O_2$.—On some new reactions of indolic bases and albuminoid compounds, by M. Julius Gnezda. When indol and its derivatives are heated with excess of oxalic acid, a fine purple coloration is developed, and a similar reaction is given by albumen, peptones, and gelatin. Some other dibasic acids may be used instead of oxalic acid. Other colour reactions brought about by hydrofluoric acid and hydrofluosilicic acid are also described.—Preliminary tests for the presence of rare metals in mineral waters, by M. F. Garrigou. In the author's opinion, the presence of rare metals of the copper and tin groups in mineral waters is more frequent than is generally supposed.—On the formation of pearls in *Meleagrina margaritifera*, by M. Léon Dignet. Genuine pearls are not simple deposits of nacreous material accidentally produced by glandular secretions, but are the result of a definite physiological action having for its aim the elimination of parasites or other causes of irritation.—On the embryogeny of *Protula meilhaci*, by M. Albert Soulier.—Regeneration of members in *Mantides* and the constant production of a tetramerous tarsus in members regenerated after autotomy in pentamerous *Orthoptera*, by M. Edmond Bordage.—On the histology of the digestive tube in the larva of *Chironomus plumosus*, by M. P. Vignon.—Contribution to the study of *Actinidia* (*Dilleniaceae*), by M. Florentin Dunac.—On the experimental production of fascicular stems and inflorescences, by M. L. Géneau de Lamarlière.—Velocity of propagation of nervous oscillations produced by unipolar excitation, by M. Auguste Charpentier.—General and local anæsthesia of motor nerves, by Mlles. I. Ioteyko and M. Stefanowska.—Physiological significance of alcohol in the vegetable kingdom, by M. P. Mazé.—On the action of currents of high frequency in arthritis, by M. Apostoli.—On the influence of electrolytic action in the production of radiographic erythema, by MM. H. Bordier and Salvador.—Further demonstrations of the variations in the amount of iron present in the tissues under the influence of pregnancy, by M. A. Charrin.

GÖTTINGEN.

Royal Society of Sciences.—The *Nachrichten* (physico-mathematical series), part i. for 1899, contains the following memoirs communicated to the Society:—

January 14.—W. Voigt: On the inflexion of plane non-homogeneous waves at the straight edge of an infinite absolutely black screen.—E. Riecke: On the work expended in producing large sparks with a Töpler induction-machine.—H. Liebmann: A new property of the sphere.—O. Mügge: On new structural faces in the crystals of unalloyed metals.

February 11.—H. Minkowski: A criterion for algebraic numbers.

February 25.—C. Runge: On the solution of certain equations with integral coefficients.—R. von Zeynek: On the irritability of sensory nerve-endings by variable currents.—W. Nernst: On the theory of electrical stimulation.—F. Nachtikal: On the proportionality between piezoelectric phenomena and the stresses that produce them.

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THURSDAY, JULY 13, 1899.

## SAUNDERS'S BRITISH BIRDS.

*An Illustrated Manual of British Birds.* By Howard Saunders. Second Edition; revised. Pp. xl + 776. Figs. and Maps. (London: Gurney and Jackson, 1897–99.)

THE demand for works on British birds shows no signs of diminution, the popularity of the present instructive volume being vouched for by the fact of the exhaustion of the first edition of 3000 copies in less than eight years from the date of completion. The first edition being out of print early in 1897, the publishers lost no time in preparing a second, which commenced in November of that year and was completed on the first of June last. That this new issue is in no sense a mere *replica* of the preceding one is at once shown by a glance at the preface, where it is stated that, while the number of species admitted as British was then 367, it has now been raised to 384. Of course, these additional species are merely stragglers; and it seems to us that, in cases like those of the frigate-petrel and the black-browed albatross, it would have been decidedly better to include such stragglers in a separate list, as they have nothing whatever to do with the true British fauna. It must, however, be admitted that in making such a list of foreign stragglers it would be exceedingly difficult to know where to draw the line, so that we are not going to blame the author for the course he has thought fit to pursue.

The accounts of the various species, although necessarily somewhat brief, are all that can be desired from a popular point of view; and as these accounts are in nearly all cases supplemented by an excellent illustration, it may be safely said that there is no other work of its size in which so much information on the subject of British birds can be obtained. The great majority of the illustrations are the same as those in the fourth edition of "Yarrell"; and although the impressions of many of these do not compare favourably when contrasted with the latter, yet their attractive character and zoological accuracy may well justify their use. New figures, by Mr. G. E. Lodge, are, however, given of many of the species recently added to the British list, while a considerable number of the old-established birds have been redrawn by the same talented artist. A special feature of the work is the carefully compiled synopsis of genera in the introduction, where all the essential diagnostic characters of each are given in simple and yet precise terms. Another notable feature is afforded by the three admirably coloured maps at the end of the volume. The first of these shows the comparative elevation of the land and the depth of the surrounding seas in the United Kingdom, while the second does the same for Europe generally. The former, as the author states, serves to remind the reader that, owing to the indentations of the coast, comparatively few spots in the British Islands are situated at a distance of more than fifty miles from the coast; and how important a bearing this has on climate—and consequently on bird-life—scarcely needs mention. The third map is a North Polar chart, embodying Nansen's discoveries; and although this is primarily intended to assist in estimating the range of Arctic-breeding species, it will be found highly useful to many others besides ornithologists.

Fortunately, Mr. Eagle Clarke's valuable digest on bird-migration appeared in time for its results to be incorporated in this volume. And how important are these results in regard to the non-continuation of the Heligoland migrations to Britain, and also in respect to the effects of wind on migration, needs no telling on this occasion.

With regard to the difficult subject of classification, we are glad to find that the author follows the lines of the last edition of "Yarrell," so that the number of families and genera is considerably less than in certain other recent manuals of British birds. We are likewise pleased to see the retention of the old ordinal names, such as Passeres and Gallinæ, instead of their fashionable substitutes Passeriformes and Galliformes. So, too, is it refreshing to notice the absence of alliterative names; the familiar goldcrest, for instance, appearing as *Regulus cristatus* instead of *Regulus regulus.*

At the same time, it is greatly to be deplored that ornithologists should not, by a system of give-and-take, come to some general agreement over what is really, in one sense, an extremely unimportant matter—*i.e.* the names and limits of the orders, families, genera, and species of British birds. In the introduction, the author observes that the limits of a genus are mainly—and often purely—a matter of convenience. With this statement we thoroughly agree; but it is surely a matter of the most extreme *inconvenience* when each and every writer on British birds adopts his own views on such limits, without any regard to those of his fellow workers.

Contrast, for instance, Mr. Saunders's classification of the *Turdidae* (Thrush family) with the grouping of the genera contained therein by Mr. Sharpe in his "Handbook of British Birds," as exemplified in the following table:—

| SAUNDERS. | SHARPE. |
|---|---|
| Fam. Turdidæ. | Fam. Regulidæ. |
| Sub-fam. Turdinæ. | 1. *Regulus.* |
| 1. *Turdus.* | Fam. Turdidæ. |
| 2. *Monticola.* | 2. *Oreocichla.* |
| 3. *Saxicola.* | 3. *Geocichla.* |
| 4. *Pratincola.* | 4. *Merula.* |
| 5. *Ruticilla.* | 5. *Turdus.* |
| 6. *Cyanecula.* | 6. *Daulias.* |
| 7. *Erithacus.* | 7. *Erithacus.* |
| 8. *Daulias.* | 8. *Cyanecula.* |
| Sub-fam. Sylviinæ. | 9. *Monticola.* |
| 9. *Sylvia.* | 10. *Ruticilla.* |
| 10. *Regulus.* | 11. *Saxicola.* |
| 11. *Phylloscopus.* | 12. *Pratincola.* |
| 12. *Aedon.* | Fam. Sylviidæ. |
| 13. *Lusciniola.* | 13. *Sylvia.* |
| 14. *Hypolais.* | 14. *Melizophilus.* |
| 15. *Acrocephalus.* | 15. *Aedon.* |
| 16. *Locustella.* | 16. *Phylloscopus.* |
| Sub-fam. Accentorinæ. | 17. *Hypolais.* |
| 17. *Accentor.* | 18. *Acrocephalus.* |
| | 19. *Locustella.* |
| | Fam. Accentoridæ. |
| | 20. *Tharrhaleus.* |
| | 21. *Accentor.* |

Here we have one author making three families out of what the other regards as one, while he expands

sixteen[1] genera of the former into twenty-one. If specific names were taken into consideration, further discrepancies would be noticeable. Moreover, in many of the other families of birds the two authors do not agree in regard to several of the generic names. For example, in the case of the ruff and reeve Mr. Saunders retains the Cuvierian *Machetes*, while Dr. Sharpe employs the earlier *Pavoncella*.

Such differences and idiosyncrasies are irritating enough to the working naturalist who knows what he is about, but to the amateur and the beginner they must be absolutely maddening. Although personally we are inclined to side with Mr. Saunders in regard to the limits of genera, and with Dr. Sharpe in regard to the adoption of the earliest names for the same, we consider both matters of no importance at all in comparison with uniformity of usage. And it is, we think, high time ornithologists settled upon some uniform working basis. Otherwise, we are of opinion the sooner scientific names are given up the better; they were intended for our tools, and we are rapidly making them our masters.

In the last few paragraphs we have departed rather widely from our text; and, to revert to the same, we may conclude by expressing the hope that the second edition of the "Boy's Yarrell," as the work before us has been not inappropriately termed, may meet with as favourable a reception from the public as has been accorded to its predecessor. R. L.

[1] *Lusciniola*, for Radde's bush-warbler, was not known to be British when Dr. Sharpe wrote.

## *AS REGARDS REGENERATION.*

*Thatsachen und Auslegungen in Bezug auf Regeneration.* Von August Weismann. Pp. 31. (Jena: Gustav Fischer, 1899.)

PROF. AUGUST WEISMANN'S essay on regeneration, which appeared simultaneously in *Natural Science* and in the *Anatomischer Anzeiger*, has now been published in pamphlet form, and well deserves the careful consideration of biologists. Its contents may be divided into two parts, the first of which is independent of the second. In the first part, Prof. Weismann expounds his previously expressed conclusion that regeneration is an adaptive phenomenon—"that the regenerative power of a part is to be considered, not as a direct and necessary expression of the nature of the organism, but rather as a capability which, though it may be absent, is found wherever it is necessary in the interests of species-preservation." In other words, the power of regenerating lost parts, though depending primarily (like all other vital qualities) on the properties of organised protoplasm, has been defined and perfected in the course of natural selection in those organisms which are in the ordinary course of their life frequently liable to serious mutilation. This is not a new idea, for, as Weismann notices, Réaumur made, in the first half of the eighteenth century, the induction that the power of regeneration was especially characteristic of animals whose brittle body was frequently liable to risk of breakage, and also of those, like earthworms, which are liable to be partially devoured. The Italian naturalist Lessona gave more precise expression to the same induction in what is sometimes called "Lessona's law," while Darwin regarded the regenerative capacity as interpretable on his theory of the selective origin of adaptations.

But since the days of Lessona and Darwin the wide occurrence of regenerative capacity throughout the animal series, till it fades away to almost nothing in mammals, has been more adequately appreciated, and besides observations not a few experiments have been made, so that the literature of the subject is already enormous Weismann, more perhaps than any other, has the credit of having recognised the importance of the problem presented, and of having tried to face the facts with a theory.

The first part of the pamphlet is an argument in favour of the interpretation of the regenerative power as an adaptive phenomenon. (1) It has been objected that regeneration sometimes occurs where the loss could only be called a casualty, and not such as would occur in the ordinary course of nature, *e.g.* a bird's regeneration of a broken beak, or a newt's regeneration of an eye. But as one inquires further into the matter it becomes probable that these injuries are much more frequent than was imagined, and that they cannot be called casualties. (2) It has been objected that internal organs not naturally exposed to mutilation or periodical wearing out are sometimes regenerated. But there seem to be few cases where this has been really substantiated, though some observations—by Vitzou, for instance, on monkeys—lead us to doubt whether Weismann is quite warranted in saying that regeneration of brain-cells in mammals never occurs. (3) T. H. Morgan's experiments on hermit-crabs showed that all the appendages were capable of regeneration, both those most liable to injury and those naturally well-protected, and led him to the conclusion that there is no relation between the frequency of loss and the regenerative capacity. With this case Weismann deals at considerable length and with his wonted ingenuity, calling to his aid especially the idea that the variation of the regeneration-"anlage" may lag behind the phyletic transformation of the part in question. But is it not enough to say that the fallacy underlying Morgan's objection is that of treating an organism as a finished product, and of assuming that an adaptation must be perfect? (4) It has been objected that regeneration does not occur in many cases where it would be very useful, thus its occurrence among reptiles, as regards the tail, is strangely sporadic, one might be tempted to say capricious. But is not this an *argumentum ad ignorantiam*, is it not likely that as we know more about the actual conditions of life in the apparently puzzling cases, the difficulties will disappear? Moreover, must it not be admitted that the absence of regeneration may be explained by the presence of another life-saving adaptation on totally different lines, and that, after all, adaptations are but compromises, and by no means perfect? Thus it is hardly an argument against the generally adaptive character of regeneration in earthworms to cite a case where the mutilated creature grows a second tail instead of a new head. One might as well say that the quickness of cerebral activity was not an effective adaptation because some people sometimes lose their heads.

But we must not prolong our review of this able essay on these familiar lines. Suffice it to say that to those who enjoy this sort of discussion, and who appreciate its serious significance, this last utterance from the renowned biologist of Freiburg—though somewhat more discursive than is his wont—will afford, as the saying is, both pleasure and profit.

The second part of the essay contains an attempt to show, not merely that regenerative phenomena are adaptive, and presumably the outcome of selection, but that they are interpretable, on the ontogenetic theory of "anlagen," "determinants," "neben-Determinanten," "reserve germ-plasm," and the like. This is quite another affair, and altogether too complex to be dealt with in a few lines. But we would venture to insist that the evolutionary or phylogenetic interpretation of regeneration phenomena as adaptive is independent of the subtler developmental or ontogenetic theory of the manner in which the capacity may be supposed to organise and express itself.

It seems to us regrettable that Prof. Weismann should condescend to notice the "invectives, sarcasm, and derision which have been showered upon" him, and that he should regard

"Such utterances as a not exactly desired, but yet not altogether unsatisfactory, sign that the less noble emotions of human nature—envy and ill-will—have found cause to direct themselves against the results of my work."

No doubt criticism without knowledge is exasperating, but it is also humbug; no doubt invective without appreciation is irritating, but it is mere pettifogging; and why should the immortals concern themselves about either?

A more philosophical temper, which we should regard as more deeply habitual, is indicated in one of the paragraphs towards the end of the pamphlet.

"One of my critics has compared my 'theories' to 'towns in the Far West,' the houses of which are barely erected when they are taken down again to be rebuilt further out in the unknown land. I accept the simile, provided it be not forgotten that the first house of the advancing pioneer must remain standing and in use for a time before the region beyond becomes accessible to further colonisation."

We would respectfully commend to the illustrious author a motto from a northern University, "They have said, What say they? Let them say." For the author of the "Germplasm" and "Germinal Selection" is surely, among living biologists, the foremost pioneer. J. A. T.

## WEST AFRICAN FETISH.

*West African Studies.* By Mary H. Kingsley. With illustrations and maps. Pp. xxiv + 639. (London: Macmillan and Co., 1899.)

FOR the last three years Miss Kingsley has been known to the scientific world as a careful collector of facts relating to West Africa, while to the unscientific public interested in works of exploration and travel she is known as a writer with an original and very entertaining manner. Her book entitled "Travels in West Africa," which was published in 1896, was the result of two journeys to West Africa, where she had devoted herself to the study of fetish and fresh-water fishes. In the preface to her present volume she tells us that her previous work, which she rather unjustly refers to as "a word-swamp of a book," was of the nature of an interim report. She there confined herself to facts, and eliminated as far as possible any inferences that might be drawn from them, distrusting at the time her own ability to make theories, and intending that ethnologists should draw from her collections of material such facts as they might care to select. The use that has been made of the volume since its appearance has certainly justified Miss Kingsley's method of publication. But there was obviously room for another work on the same subject from her pen. No one was better qualified than herself to form opinions with regard to the beliefs and practices she studied, and we are glad to find that in the present work she has formulated the conclusions at which she has arrived. We welcome the book as a valuable supplement to the first volume of her travels.

The book contains a good deal or very varied information, and while some portions of it appeal to the anthropologist and student of religion, others deal with purely scientific observations, and others again are of a political nature. Miss Kingsley's criticism of the Crown Colony system will doubtless receive the attention it deserves at the hands of those who are responsible for the methods we adopt as a nation in dealing with our tropical possessions. Her chapter entitled "Fishing in West Africa," which has already appeared in the *National Review*, explains the means by which she was enabled to form the collections which won Dr. Günther's admiration; while in the same connection we have an interesting account of the little fishes (*Alestis Kingsleyae*) which have the honour to bear their discoverer's name. The most interesting part of the book, however, which Miss Kingsley herself regards as of greatest importance, is the section which deals with the subject of fetish in West Africa. The word fetish is used by Miss Kingsley in a much wider sense than that in which it is generally employed at the present day. The word was adopted into scientific literature from the writings of the old Portuguese navigators, who were the modern discoverers of West Africa. These men noticed the veneration paid by Africans to inanimate objects, and called these things *Feitiço*, a term they applied to their own talismans and charms. The word is nowadays generally employed in a rather similar sense as a general term for the doctrine of spirits embodied in, or conveying influence through, material objects. Miss Kingsley, however, in spite of a protest from Prof. Tylor, has thrown over this established usage, and employs the word as a convenient synonym for the religion of the natives of the West Coast of Africa where they have not been influenced either by Christianity or Mohammedanism. Using the term with this extended application, Miss Kingsley classifies West African fetish into four main schools: the Tshi and Ewe school, which is mainly concerned with the preservation of life; the Calabar school, which attempts to enable the soul to pass successfully through death; the Mpongwe school, which aims at the attainment of material prosperity; and the school of Nkissi, which chiefly concerns itself with the worship of the power of the earth. These schools of fetish are not sharply defined, and many of the same

things are worshipped indiscriminately in each; but Miss Kingsley has shown that in certain schools certain ideas are predominant, and her classification is based on a general survey which can afford to ignore minor inconsistencies. It is interesting to note that, according to Miss Kingsley's observations, the African, to whatever school of fetish he may belong, conceives of a great over-God, who has below him lesser spirits including man. But this fact does not necessarily support Mr. Andrew Lang's recently promulgated theory as to the original purity and elevation of the religious beliefs of primitive races, though Miss Kingsley herself is inclined to identify her own conception of things with that she found current among the peoples she studied. We have merely touched on the principal sections of Miss Kingsley's very interesting work, and have not space to do more than recommend its perusal to all those interested in the religions of the undeveloped races of mankind. The reader will find in it much material of the greatest scientific importance, while its anecdotes and lively style render it one of the most entertaining books of travel and observation that has appeared for many years.

## *OUR BOOK SHELF.*

*Catalogue of the Library of the Royal Botanic Gardens, Kew.* (London, 1899.)

THE issue of this catalogue fittingly commemorates the development, up to the last year of the nineteenth century, of an adjunct indispensable in the equipment of a centre of botanical research so deservedly famous as the Royal Botanic Gardens at Kew. The many botanists that have enjoyed the access to the library so freely allowed to workers in the Herbarium, and have learned to value the stores of information contained in it, will rejoice to have the catalogue as a guide to render the riches of the library still more accessible than in the past. But not to those alone that can visit Kew Herbarium is it likely to be welcome. Botanists living at a distance that precludes frequent visits to Kew Herbarium will find it most useful for reference as a guide to the literature of botany, and will value it accordingly.

The size of the library may be judged from the fact that a rough calculation shows upwards of 15,000 separate entries of books or papers, besides numerous cross-references. Of course, all sides of botanical research are represented, from the more elementary to the most profound, from the most rigid study of botany as pure science to its practical applications to industries and arts, to folk-lore, and to its manifold links with other fields of study, scientific and literary. Occasionally one meets with a title that at the first glance seems to have little connection with botany, *e.g.* W. Ridgeway's "The Origin of Metallic Currency and Weight Standards," yet these only serve to show the curious relations of botany to other studies.

The entries are divided into four series, each arranged alphabetically:—(1) General, occupying 683 pages; (2) Travels, 43 pages; (3) Periodicals and Serials, 47 pages; (4) Manuscripts, 15 pages, large octavo.

The catalogue has been prepared by Mr. B. Daydon Jackson, and is marked by the accuracy so characteristic of all his work in botanical bibliography. Despite the peculiar risk of errors in transcribing and printing the titles and necessary details, many of which are in very unfamiliar languages, the freedom from errors is very noteworthy.

An introduction to the volume from the pen of the Director of the Gardens gives a brief account of the leading facts in the formation of the library, which originated as a public library in 1852, when Miss Bromfield presented to the Gardens the botanical books that had belonged to her deceased brother, Dr. W. A. Bromfield. Sir William Hooker, on his appointment as Director in 1841, had offered to make his large private library and herbarium available for public use if they were suitably accommodated. This was done in a house provided for him as Director until 1852, when they were transferred to the present Herbarium, though still remaining his private property. In 1854 the late George Bentham, F.R.S., very generously gave his large botanical library to the Herbarium, where in subsequent years he long continued those researches by which he so greatly advanced the science of botany. In 1867, after Sir William Hooker's death, the Treasury sanctioned the purchase for the library of those botanical works that had belonged to him and that the library did not possess.

Valuable legacies and gifts have also been received from other sources, and numerous serials are obtained in exchange; and purchases are made with occasional grants from the Bentham Trust. The sum expended from public funds in the formation of the library has been very small in comparison with its value, and has consisted of a small annual subsidy since 1849, supplemented after some years by free binding by the Stationery Office. One important source of constant additions—the gifts of books and separate papers from the authors—is largely the result of the benefits experienced by the botanists that come from far and near to pursue researches at Kew.

The catalogue would become still more valuable to botanists if there could be added a subject-division, even under large sections, of the multitude of titles that it contains. The difficulties of doing so are indeed considerable, but the aid to workers would be very great.

*The Larvae Collector's Guide and Calendar.* By J. and W. Davis. Pp. 90. (Dartford: J. and W. Davis.)

THE times of the appearances of the British macrolepidoptera are given in this little book, together with notes on rearing lepidoptera from eggs, larvæ, and pupæ. Young naturalists should find the volume useful in stocking their butterfly cages, and as a guide to the management of insects in the different stages of development.

## *LETTERS TO THE EDITOR.*

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### A Lecture Experiment on the Relative Thermal Conductivities of Various Metals.

MOST lecture experiments on the conductivities of metals occupy too much time to be very effective, and in addition are often somewhat uncertain in their action. The following arrangement may be very quickly and simply put together, and by its aid the relative conductivities of a number of metals may be quantitatively determined in an interval of about a minute, the essential parts of the apparatus being capable of projection on a screen.

A piece of brass tube, about 10 cm. in diameter and 20 cm. in length, is closed at one end by means of a brass disc. A number of holes are bored in this disc to receive the extremities of rods of copper, brass, iron, &c., each rod being 2·5 mm. in diameter and about 15 to 20 cm. in length. The rods are soldered in position perpendicular to the disc.

Each rod is provided with a small index, made from a piece of copper wire of about ·8 mm. diameter, bent into the form shown in Fig. 1, a small arrow-head of blackened paper or mica being attached by shellac varnish. The rings forming part of each index are wound on a rod *very slightly* larger in diameter than the experimental rods.

To start with, the brass vessel is inverted, an index is slipped

on each rod, the single ring (Fig. 1) being left in contact with the disc, and a very small amount of paraffin wax is melted round the rings. When the vessel is supported with the rods downwards, as in Fig. 2, the solid wax holds the indexes in position. The arrangement is then placed between the condenser and the focussing lens of the lantern, and boiling water is poured into the brass vessel. When that part of a metal rod, in the neighbourhood of the double ring of the index, reaches the

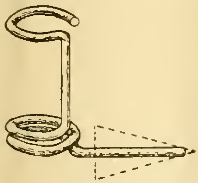

FIG. 1.—Enlarged view of index.

melting temperature of the wax, the index commences to slip downwards, carrying the wax with it, and when the temperatures of the rods have acquired steady values, the indexes will have descended to points on the various rods where the wax just solidifies, and which, therefore, possess equal temperatures. Hence, the conductivities of the various rods are proportional to the squares of the distances from the bottom of the brass vessel to the respective positions indicated by the several arrow-heads.

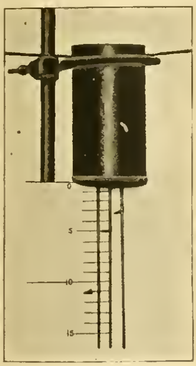


FIG. 2.—Lecture apparatus for demonstrating the relative thermal conductivities of metals. (The left-hand rod is of copper, the middle one of brass, and the right-hand one of soft steel.)

A scale of equal parts, or, better still, a scale of squares, may be drawn on the screen, when the relative conductivities may be directly read off.

In Fig. 2, rods of copper, brass and soft steel are shown with the indexes in the positions acquired at the end of an experiment. It will be seen that the relative conductivities work out to within three or four per cent. of the accepted values for the mean conductivities between 0° and 100° C.

Royal College of Science, July 8. EDWIN EDSER.

## The Electrical Resistance of the Blood.

IT is no easy task to measure the electrical resistance of the blood of a living individual. The principal difficulty depends upon the fact that only very small quantities of blood can generally be obtained at a time. During the last five years many attempts have been made by me to obtain trustworthy and consistent results; various methods and forms of apparatus have been employed and subsequently rejected.

The best results were obtained by placing five cubic millimetres of freshly-drawn blood between two cup-shaped electrodes three millimetres in diameter, coated with spongy platinum, and fixed at 0·75 mm. apart.

The average resistance of normal blood at 60° F. measured by Kohlrausch's method in this apparatus is 550 ohms. A striking change may be observed in pernicious anæmia, the resistance in this disease being sometimes diminished to about one-half that of normal blood. The deduction is that the blood in pernicious anæmia contains an abnormal amount of salts, due to the destructive metabolism going on.

DAWSON TURNER.

## School Laboratory Plans.

I HAVE long believed that by far the best arrangements of the benches in a laboratory for elementary chemical teaching is the last one suggested by Mr. Richardson, viz. "single benches, cross-ways, like the desks of an ordinary class room."

It must be remembered that qualitative analysis now occupies a secondary place in an elementary course, and a great number of reagents is not required for preparations and simple quantitative experiments. The superstructure of shelving may therefore be replaced by a single rack for the common reagents. This allows perfect supervision from the raised demonstration table in front of the benches, and the work of the class can at any moment be interrupted for explanation or revision of the work done, or for an experiment made by the master himself. It is surely a mistake to divide an elementary course of chemistry into two parts—theoretical and practical; the proposed arrangement allows of the practical work forming a part of the general course.

In this county this arrangement has been successfully carried out. The grammar schools are, however, unwilling to risk the refusal of the Science and Art Department to recognise such a laboratory for earning grants, the old-fashioned benches with uncleanly teak tops and rarely used drawers and cupboards being usually insisted on. T. S. DYMOND.

County Technical Laboratories, Chelmsford.

## The Origin of the Doctrine of Compensation of Errors in the Infinitesimal Calculus.

I SHOULD be much obliged if you could help me by inserting a query on this point.

Lazare Carnot, at the end of his "Reflexions sur la Métaphysique du Calcul Infinitésimal," stated that "it is singular that in this indispensable condition of elimination the real character of Infinitesimal Quantities . . . should not hitherto have been discovered."

However, Lagrange (see "Œuvres," t. vii. p. 595) had explicitly stated this doctrine many years before. Very possibly Carnot did not see this note, but Lagrange again stated it in the preface of his "Théorie des Fonctions Analytiques," which Carnot had certainly seen, as he quoted some passages from it in the later editions, at least, of his "Reflexions."

If Carnot has any right to an independent discovery, he could hardly have quoted Lagrange in the first edition of his work. The first edition of both Carnot's and Lagrange's works was dated 1797.

I have been unable to find a first edition of "Carnot" here, so write to ask if any one can tell me whether there is any mention or quotation of Lagrange in it. PHILIP E. B. JOURDAIN.

63 Chesterton Road, Cambridge, June 30.

## Robert Browning and Meteorology.

ROBERT BROWNING'S well-known description of Aurora Borealis, in "Easter Day" (c. xv. xvii), is so graphic that it must have been written from personal observation. Probably few persons can fully appreciate its accuracy; but on September 24, in that wonderful Aurora year 1870, just such a display took place, which I had the fortunate opportunity of watching nearly all night from the Welsh hills, when all the phenomena Browning describes, and many others, were abundantly visible. But I can find no account of any such display having been seen in these latitudes earlier in the century, and "Easter Day" dates from 1850.

The lunar rainbow in "Christmas Eve" (c. iv. and vi.), which "rose at the base with its seven proper colours chorded,"

blending at the summit "in a triumph of whitest white," with a second bow above it, and "a wondrous sequence" beyond that, is evidently the hybrid offspring of fancy and that inaccurate observation of phenomena which seems inevitable without scientific training, especially as, while evening service is going on in Zion Chapel, the moon's "full face" is shining in the West, and the bow appears in "the *empty* other half of the sky," "North and South and East." The effect of "the flying moon" trying to break out of its "ramparted cloud prison" is, however, very graphically described.

But I should like to know when and where the poet could have seen his Aurora. B. W. S.

July 8.

### A Plague of Frogs.

THIS afternoon, as I was walking into Lickey Village from King's Norton, I came across innumerable frogs. They lined the hedges and covered the road so thickly that I had to walk on tiptoe. I thus proceeded quite 400 yards, where the phenomenon ended as sharply defined as it had begun. Nowhere else along the road was a frog to be seen. I was particularly astonished, as I knew the nearest water to be the Little Reservoir—quite $\frac{1}{2}$ mile away. The frogs were about ten days old, very small. A cottage stood about 300 yards from the beginning of this swarm. Upon inquiry I ascertained that the frogs had thus congregated since noon on Monday, that they had literally besieged the house, jumping all over the ground-floor rooms, that the garden and its paths were full of them. The present occupants had lived there $4\frac{1}{2}$ years, but had never experienced anything like this. They have sometimes seen a few frogs cross the road in wet weather. They are now occupied with brushing them out of doors. Can any of your readers explain the cause of this extraordinary spectacle?

King's Norton, Birmingham, July 5. F. H. FORTEY.

## *THE UNIVERSITY OF LONDON.*

AS we went to press last week, an adjourned meeting of the Senate of the University of London was being held to discuss the report of the special committee appointed to consider the offer of the Government to house the University in the Imperial Institute. The history of the negotiations that have taken place may be read in the abridged report published in last week's NATURE; and the facts contained in that statement formed the basis of the discussion in the Senate. In the end the offer of the Government was accepted, the following resolution, proposed by Sir Edward Fry and seconded by Mr. Bryce, being carried by a large majority:

"That the Senate accepts the proposal of Her Majesty's Government as far as it provides in the buildings of the Imperial Institute accommodation for the work hitherto done by the University; and authorises the Committee consisting of the Chancellor, the Vice-Chancellor, and Sir J. G. Fitch to settle the formal terms of agreement with the Government, and the Senate reserves the right of the University to hereafter request the Government to make further provision for such further needs as may arise in the future."

By this resolution the question of the future headquarters of the University is practically settled. The schemes of organisation of the constituent Colleges of the University and future possible teaching centres are now matters of the highest importance, for by them the future work and influence of the University will be determined. An ideal University should encourage the advancement of every branch of knowledge which assists human progress, and it can only do this by admitting into its constitution all subjects with which men of "light and leading" are concerned. It can hardly be held that the University of London has satisfied these conditions in the past, but under the new constitution we may confidently hope that a wider view will be taken of its functions and responsibilities. We have no longer to deal merely with a body authorised to confer degrees by examination, but with a living organisation taking part in the actual work of instruction. The teachers in this great University will feel that the interests of the University are their own interests, and that their work is not to have for its end the preparation of candidates for degrees, but to encourage students to work for the dignity and influence of their *alma mater*.

There are several directions in which the work of the University ought to be developed. Law and medicine should, of course, have their Faculties, as they have in the Universities of Paris, Bologna and elsewhere; and we may surely look to those institutions which have for centuries kept the lamp burning in the absence of a University for the needed heip. Higher commercial education can be provided for by the establishment of a School of Economics and Political Science organised at the Imperial Institute itself. The exceptional facilities offered by the Institute for the work of a school of this character were referred to in an article in NATURE of April 20 in the following words:

"The well-arranged collections of Indian and Colonial products, which form a most important part of the equipment of the Imperial Institute, would be found of especial value in illustrating the teaching of that branch of commercial education known as *Waarenkunde*. Nowhere else in London do similar facilities exist for instruction in the technology of commercial products. Within the building, too, has been provided a chemical laboratory, which is now largely used for the examination and analysis of foreign products; and much of the scientific investigation therein carried on, under the able direction of Prof. Dunstan, is an essential feature in the programme of a high school of commerce. Indeed, a large part of the work which entered into the original scheme of the promoters of the Imperial Institute might, it would seem, consistently, and with great advantage to the public, be continued in that Institute under the auspices of a school of economics, industry and commerce, in connection with the reconstituted University of London. Whether such an arrangement can be effected is a matter for careful consideration; but there is no doubt that the association with the new University of a school of 'economics and political science,' under a separate Faculty, suggests a reasonable basis of union between the educational side of the Imperial Institute and the future University of London."

In connection with this suggestion, another point well deserves consideration. The support which the Colonies have given to the Institute has been in some cases withdrawn on the ground that no advantage was derived from it. But with a commercial school at the Institute colonial students could come over to pursue their studies in the midst of collections illustrating the products of their homes, and the training they would receive with such an environment would ultimately be used for the benefit of the Colonies, so that an adequate return would be made for whatever support was given. In fact, it seems that the use of the collections for the purposes of instruction in connection with the new University would satisfactorily settle the question of the service of the Institute to the Colonies, as well as give colonial students an opportunity of obtaining a degree under the very best conditions.

If the example is once set by using the Institute collections to illustrate courses of instruction on colonial products and industries, it is to be hoped that the other special collections which abound in London illustrating many other branches of culture may also be utilised for University purposes. With its new resources and facilities for advanced teaching, the University is given the opportunity of widely increasing its sphere of influence; and friends of education and national progress look to it to make the best use of the opportunities which the new headquarters will afford.

## THE LIFE OF A STAR.

### A LETTER FROM PROF. PERRY TO SIR NORMAN LOCKYER.

YOU have asked me to examine certain publications on this subject, and to give you my views on the value of such speculations as have been made by mathematical physicists.

Mr. T. J. J. See (*The Astronomical Journal*, Boston, February 6, 1899) states as "one of the most fundamental of all the laws of nature" that gaseous masses follow the law

$$t = \frac{K}{R}$$

where K is a constant for all stars of whatever mass or of whatever kind of gaseous stuff, R is the radius and $t$ is the temperature. Now we have all sorts of temperatures in a star; but whether Mr. See takes average temperature or the temperature of some layer at a definite depth below the surface, he is certainly wrong. Mr. Homer Lane does not express the general results which I shall give presently, nor does Lord Kelvin give them in my form (although he does give them); but from either of these classical papers Mr. See might have inferred them, and seen that his own statement was wrong. Mr. See's arguments are really metaphysical. For example, at the very beginning of the proof of his proposition he speaks of the gravitational pressure at the surface of a star, whereas in physics we do not admit that there can be such a pressure in the absence of outside matter. Thus it is impossible for a mathematical physicist to get to Mr. See's point of view.

Of A. Ritter's articles in *Wiedemann's Annalen* there is a good abstract in the *Astrophysical Journal*, Chicago, December 1898. He assumes that the radiating layer on the outside of a star is of constant mass. He also assumes that the rate of radiation is proportional to the fourth power of the average temperature of this layer. He is dealing with temperatures which are so much greater than the temperatures with which we work in the laboratory, that such assumptions must be regarded as quite arbitrary.

Mr. Homer Lane, in his classical paper on the theoretical temperature of the sun (*American Journal of Science and Arts*, second series, vol. l. p. 57, 1870), makes the assumption that Dulong and Petit's law of radiation is true for solar radiation, and he uses it to calculate the temperature of the radiating layer, which he finds to be 28,000° F. That is, he uses an empirical law, obeyed possibly at laboratory temperatures in radiation from hot solids, to express the radiation at enormous temperatures from a hot layer of gas which has layers of gas of all sorts of temperatures above and below it.

It seems to me that we know too little about the phenomenon of radiation from layers of gas with denser and hotter layers below and rarer and colder layers above to allow of any weight being placed upon these assumptions of Ritter or Homer Lane. In a star we have layers of fluid at all sorts of temperature and density. We have no laboratory knowledge of radiation that is applicable. We know very little about any star except our own sun. During Palæozoic time, many millions of years, there has been life on our earth. Prof. Newcomb is of opinion that the sun's heat received by the earth cannot have varied more than a very little during Palæozoic time. My results will enable us to see what this uniformitarian assumption leads to. It is my own belief (see NATURE, p. 582, April 1895) that there may have been many millions of years during which the sun may have been radiating at only one-third or one-tenth of its present rate. My formulæ will enable us to apply such assumptions as these, and see what they lead to. However different assumptions of this kind may appear to be, they all lead to results which only differ in degree, and not in kind. Assumptions like those of Homer Lane and Ritter may lead to results which are altogether wrong.

All this is speculation, but it is speculation on physical and mathematical lines where criticism is immediately applicable to one's logic and one's premises.

#### *Gaseous Stars.*

Homer Lane, Lord Kelvin, Ritter, and all people who have tried to make exact calculations, have assumed that the stuff of which a star is composed behaves as a perfect gas in a state of convective equilibrium. I also assume that this is the case. But if we apply our results to our own sun, we find that at its centre there is a density 33, that is, 50 per cent. greater than the ordinary density of platinum. It seems to me that speculation on this basis of perfectly gaseous stuff ought to cease when the density of the gas at the centre of the star approaches 0·1 or one-tenth of the density of ordinary water in the laboratory.

Let $\rho$ be density, $t$ absolute temperature, $p$ pressure of the gas at the distance $r$ from the centre; the gas is such that $\rho\sigma t = p$, $\sigma$ being a constant depending on the nature of the gas, and let $\gamma$ be the ratio of its specific heats. Let there be convective equilibrium, so that

$$\rho t^{1/(1-\gamma)} = c_1, \text{ a constant} \quad \ldots\ldots (1)$$

or

$$p t^{\gamma/(1-\gamma)} = c_3, \text{ a constant} \quad \ldots\ldots (2)$$

Let $t_0$ and $\rho_0$ be values at the centre of the star.

If $m$ is the mass inside the radius $r$, then

$$\frac{dp}{dr} = -a\frac{m}{r^2}\rho \quad \ldots\ldots\ldots\ldots (3)$$

[I introduce the constant $a$ because $\frac{m\rho}{r^2}$ is the gravitational force with which a mass $m$ attracts a mass $\rho$ at the distance $r$. If we keep $a = 1$, all our forces will be in gravitational units. I prefer to have them in laboratory units. If we keep to C.G.S. units throughout, as one dyne is the weight of one gramme at the earth's surface $\div 981$ and the weight of one gramme corresponds to $\frac{M_1}{R_1^2}$ gravitation units, where $M_1$ is the mass of the earth in grammes and $R_1$ is the radius of the earth in centimetres; one dyne corresponds to $\frac{M_1}{981\ R_1^2}$ gravitation units, so that

$$a = \frac{981\ R_1^2}{M_1}\Big].$$

Also

$$m = 4\pi\int_0^r r^2\rho\ .\ dr \quad \ldots\ldots\ldots (4)$$

(3) is the same as

$$r^2\frac{c_3}{c_1}\frac{\gamma}{\gamma-1}\frac{dt}{dr} = -am \quad \ldots\ldots\ldots (5)$$

From (4),

$$\frac{dm}{dr} = 4\pi r^2\rho = 4\pi r^2 c_1 t^{\frac{1}{\gamma-1}}.$$

Hence, differentiating (5), we have

$$\frac{d^2t}{dr^2} + \frac{2}{r}\frac{dt}{dr} + \frac{4\pi a(\gamma-1)\rho_0 t^{1/(\gamma-1)}}{\sigma\gamma\ \ t_0^{1/(\gamma-1)}} = 0 \quad \ldots\ldots (6)$$

Let us assume that $t = t_0\theta$, and that $r = bx$, choosing $b$ so that $x$ and $\theta$ shall not depend upon $t_0$ or $\rho_0$, and that the coefficient of the last term is 1, thus we find

$$\frac{d^2\theta}{dx^2} + \frac{2}{x}\frac{d\theta}{dx} + \theta^{1/(\gamma-1)} = 0 \quad \ldots\ldots (7)$$

an equation which is true for any star the $\gamma$ for whose gaseous stuff is known.

$\theta$ which is $t/t_0$ may be expressed as a sum of powers of

$x$, and so tabulated. In the same way, $\phi$ or $\rho/\rho_0$ might be tabulated. Indeed $\phi^{\gamma-1}=\theta$. Again $\mu$ or $\int_0^x \phi x^2 . dx$ may be tabulated. Mr. Lane has done this work for several values of $\gamma$. Solution by means of series of powers of $x$ can be relied upon only till $x=1$. After that one must work indirectly. Lord Kelvin, in a paper published in the *Philosophical Magazine*, 1887, vol. xxiii. p. 287, gives numbers calculated by his assistant, Mr. Magnus Maclean, from which, with the help of Mr. J. Lister's or Mr. Homer Lane's values at $x=1$, I could give a table like the following for the case of $\gamma=1{\cdot}4$. There are outside limits for $x$ and $\mu$, which Mr. Lane calls $x'$ and $\mu'$. Knowing the value of $\theta$ for $x=1$, I find that Lord Kelvin's numbers give $x'$ as 5·24, and the corresponding $\mu'$ as 2·165, whereas Mr. Lane gives $x'$ as 5·35, and $\mu'$ as 2·188. Mr. Lane does not publish the other values, and his curves are drawn to too small a scale for us to be able to make out tables of the values of $\theta$ or $\phi$. Lord Kelvin from $x=0$, and Mr. Lane for values beyond $x=1$, obtained their results by methods such that errors may have increased as the work proceeded.

On the whole, I am disposed to take Lord Kelvin's numbers with an $x'$, which is the mean of those just given, or 5·30, and $\mu'$ as 2·177.

TABLE I.—*For Gaseous Stuff whose Specific Heat Ratio is* 1·4.

| $x$ | $\theta$ | $\phi$ | $\mu$ |
|---|---|---|---|
| 0 | 1·000 | 1·000 | 0 |
| ·795 | ·904 | ·777 | ·136 |
| ·883 | ·884 | ·734 | ·184 |
| ·993 | ·857 | ·679 | ·252 |
| 1·14 | ·819 | ·607 | ·355 |
| 1·33 | ·763 | ·508 | ·512 |
| 1·59 | ·681 | ·385 | ·758 |
| 1·99 | ·562 | ·237 | 1·133 |
| 2·65 | ·384 | ·0916 | 1·666 |
| 3·97 | ·141 | ·0074 | 2·117 |
| 5·30 | 0 | 0 | 2·177 |

We know now that for any star whose stuff behaves like a perfect gas

$$\left.\begin{array}{l} r=\mathrm{A}\left(\dfrac{t_0}{\rho_0}\right)^{1/2}x,\ m=\mathrm{B}t_0^{3/2}\rho_0^{-1/2}\mu \\ t=t_0\theta,\ \rho=\rho_0\phi \end{array}\right\} \quad . \ . \ . \ . \ . \ (8)$$

Where

$$\mathrm{A}=\sqrt{\frac{\sigma\gamma}{4\pi a(\gamma-1)}},\ \text{and}\ \mathrm{B}=4\pi\mathrm{A}^3.$$

we see that A and B, $x'$ and $\mu'$ depend merely on the nature of the gas. We have

$$\mathrm{R}=\mathrm{A}\left(\frac{t_0}{\rho_0}\right)^{\frac{1}{2}}x' \quad . \ . \ . \ . \ . \ . \ . \ . \ (9)$$

$$\mathrm{M}=\mathrm{B}t_0^{3/2}\rho_0^{-\frac{1}{2}}\mu' \quad . \ . \ . \ . \ . \ . \ . \ . \ (10)$$

if R is the outside radius and M is the whole mass.

We may choose values of $t_0$ and $\rho_0$, and calculate R and M, or it is easy to see that if we know R and M, we may calculate the internal density and temperature by

$$\left.\begin{array}{l} t_0=\dfrac{x'}{4\pi\mathrm{A}^2\mu'}\cdot\dfrac{\mathrm{M}}{\mathrm{R}} \\ \rho_0=\dfrac{x'^3}{4\pi\mu'}\,\dfrac{\mathrm{M}}{\mathrm{R}^3} \end{array}\right\} \quad . \ . \ . \ . \ . \ . \ . \ (11)$$

It will be noticed that, $\sigma$ being proportional to the molecular volume (being sixteen times as great in hydrogen as in oxygen), $\rho_0$ is independent of $\sigma$, whereas $t_0$ is inversely proportional to $\sigma$. If we consider our own sun to be made of hydrogen, and if the laws of perfect gases could be applied as we have applied them, $t_0 = 3{\cdot}25 \times 10^7$ degrees centigrade, $\rho_0 = 33$, that is, 50 per cent. greater than the density of platinum (see how I blush). Whereas if it were made of oxygen, $\rho_0$ is the same as before, but $t_0$ is $2{\cdot}03 \times 10^6$ degrees. It is sometimes good to employ, instead of (8)

$$\left.\begin{array}{l} r=\dfrac{\mathrm{R}}{x'}x,\ m=\dfrac{\mathrm{M}}{\mu'}\mu \\ t=\dfrac{\mathrm{M}x'}{4\pi\mathrm{A}^2\mathrm{R}\mu'}\theta,\ \ \rho=\dfrac{\mathrm{M}x'^3}{4\pi\mathrm{R}^3\mu'}\phi \end{array}\right\} \quad . \ . \ . \ . \ . \ (12)$$

The above tables and these formulæ enable us to find the temperature and density at any point in any gaseous star of any mass, size and material (if $\gamma$ is 1·4). The curve connecting $\theta$ and $x$ is the $t$, $r$ curve for any star; the curve connecting $\phi$ and $x$ is the $\rho$, $r$ curve for any star; the scales of measurement are given in (12).

The *intrinsic energy* (not including any gravitational energy) of the whole mass being $h$, since the intrinsic energy of unit mass at temperature $t$ is $kt$, if $k$ is the specific heat (in ergs) at constant volume, and $t$ is $t_0\,\rho_0^{1-\gamma}\,\rho^{\gamma-1}$,

$$h=4\pi k t_0\rho_0^{1-\gamma}\int_0^{\mathrm{R}} r^2\rho^{\gamma}\,.\,dr$$

or

$$h=4\pi k\mathrm{A}^3 t_0^{5/2}\rho_0^{-\frac{1}{2}}\mathrm{X}$$

if X stands for

$$\int_0^{x'} x^2\theta^{\gamma/(\gamma-1)}dx$$

a known number depending only on the value of $\gamma$. Hence

$$h=\frac{k\mathrm{X}x'}{4\pi\mathrm{A}^2\mu'^2}\cdot\frac{\mathrm{M}^2}{\mathrm{R}} \quad . \ . \ . \ . \ . \ . \ . \ . \ (13)$$

If W is the *work done by gravitation* in bringing all the stuff into its present position from an infinite distance,

$$\mathrm{W}=a4\pi\int_0^{\mathrm{R}}\rho m r\,.\,dr=a\mathrm{Y}\frac{x'}{\mu'^2}\cdot\frac{\mathrm{M}^2}{\mathrm{R}} \quad . \ . \ . \ (14)$$

where

$$\mathrm{Y}=\int_0^{x'}x\mu\phi\,.\,dx$$

a known number depending only on the value of $\gamma$.

We can now speculate on these results. If the pieces of stuff which come together to form the nebula are not mere molecules, but of the size of meteors such as reach our earth, W will not be much less than what is here stated. Indeed, we may say that even when a star ceases to be gaseous, and throughout its whole history the value of W is so nearly what is given in (14), that (14) may be used generally in such speculations as these.

A gaseous star doubles all its temperatures and its intrinsic heat energy when its radius is halved. We see that if all stars are of the same gaseous stuff, the ratio of $h$ to W is constant for all stars at all times. Let us put $\mathrm{W} = a\,\dfrac{\mathrm{M}^2}{\mathrm{R}}$, $h = \beta\,\dfrac{\mathrm{M}^2}{\mathrm{R}}$

As $\mathrm{W} = h + \mathrm{H}$ if H is the total energy lost by the star by radiation, then

$$\mathrm{H}=(a-\beta)\frac{\mathrm{M}^2}{\mathrm{R}} \quad . \ . \ . \ . \ . \ . \ . \ . \ (15)$$

As part of this heat was lost by the stuff before it became a spherical gaseous star, we may take as the heat lost from time $\mathrm{T} = 0$ when the radius was $\mathrm{R}_0$ to the present time T, when the radius is R

$$(a-\beta)\mathrm{M}^2\left(\frac{1}{\mathrm{R}}-\frac{1}{\mathrm{R}_0}\right) \quad . \ . \ . \ . \ . \ . \ . \ (16)$$

In the mass M there are surfaces whose areas are proportional to $\mathrm{R}^2$, and whose temperatures are proportional to $\dfrac{\mathrm{M}}{\mathrm{R}}$. I shall assume as quite reasonable, that

$$\left.\begin{array}{r}\text{Total radiation per}\\ \text{year from a star}\end{array}\right\}\propto \text{areas}\times(\text{temperatures})^n \quad . \ (17)$$

where $n$ is some constant.

It may be worth while here to use with this the assumption that our sun, when gaseous, radiated heat of the same amount every year; of course H of (15) or (16) is then proportional to time. (15) is the age of the sun from some zero of time until it had the radius R; (16) is the time taken to contract from radius $R_0$ to radius R.

Using (17),

$$\text{Rate of total radiation} \propto R^2\left(\frac{M}{R}\right)^n \quad . \quad . \quad . \quad . \quad (18)$$

we see that $n$ must be 2 for our sun. In our state of ignorance of the phenomenon of radiation from a star it may be presumptuous in me to say that this would be a very reasonable *à priori* assumption. Namely that rate of radiation is proportional to surface and square of average temperature. Anyhow it makes the task of pursuing the uniformitarian assumption less thankless.[1]

For any star then the total radiation in unit time is proportional to $M^2$, and hence the time taken by any gaseous star in contracting from radius $R_0$ to radius R is

$$T \propto \frac{1}{R} - \frac{1}{R_0} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

being the same for any star, whatever its mass may be. How it depends on the nature of its material we do not know, as we are basing these speculations on an assumption as to the sun's radiation. Or counting *age* from some period in the nebulous state, which it is not easy to define.

$$\text{temperature of star} \propto \text{age} \times \text{mass} \quad . \quad . \quad . \quad . \quad (20)$$

We see that stars get to have higher and higher temperatures as they get older, until they cease to behave as gaseous bodies throughout. The temperature outside is 0. The depth below the surface at which there exists a layer of a particular temperature, say 5000° Cent. absolute, is proportional to $R^2/M$, or if our rule as to time is right, the depth is inversely as the mass of a star multiplied by the square of its age. In a very old, massive star the layer at 5000° is very close to the outside.

It seems to me that this is an important thing. A young star, a truly gaseous star, has great depth of radiating layer. I mean it is probably only at great depths from the free surface that we find the layer from which a continuous spectrum comes. I take it that it is only during collision of molecules that a continuous spectrum is given out; in the free-path state of a molecule it radiates its own light only. Great density and high temperature conduce to the giving out of the continuous spectrum. In old stars, like our sun, the layer of stuff capable of giving out white light is comparatively near the surface of the star. I can imagine a comparatively young star long before its heat energy is a maximum, not radiating energy very fast, but rather giving out bright line spectra light from the greater part of its area; in fact from all but its central parts.

I am very ignorant of your subject, but I take it that any star gives out a continuous spectrum with lines. The continuous spectrum is strong, and the lines relatively dark, in old stars; the continuous spectrum is weak, and the lines bright, in new stars. In both cases the continuous spectrum is most intense, and the lines least intense at the central parts of a star. If a star is very new, so that it is not all gas, it will probably not be spherical, and one may have spectra quite different in different places and at different times.

[1] If total radiation from a star is proportional to surfaces × the $n$th power of temperatures

$$\frac{dH}{dT} \propto M^n R^{2-n}$$

but from (16),

$$\frac{dH}{dT} \propto -\frac{M^2}{R^2}\frac{dR}{dT}$$

Putting these equal and integrating we find T as the time since the star was of radius $R_0$

$$T \propto \left(R_0^{n-3} - R^{n-3}\right)\frac{M^{2-n}}{n-3}$$

I. Thus if $n=1$,

$$T \propto M\left(\frac{1}{R^2} - \frac{1}{R_0^2}\right)$$

It follows from this assumption that the rate of increase of temperature per annum is proportional to $\frac{\text{Mass}}{\text{temperature}}$.

II. If $n=2$ as above,

$$T \propto \frac{1}{R} - \frac{1}{R_0}.$$

It follows from this that the rate of increase of temperature per annum is constant and is proportional to the mass of the star.

III. If $n=3$,

$$T \propto \frac{1}{M}\log\frac{R_0}{R}.$$

It follows from this that the temperature increases with time by the compound interest law; that is, the rate of increase of temperature per annum is proportional to the mass × temperature.

IV. If $n=4$,

$$T \propto \frac{1}{M^2}\left(R_0 - R\right).$$

In this case the rate of increase of temperature per annum is proportional to the square of the temperature.

Suppose it to be assumed that the radiation is mainly from an outer layer, that this layer increases in temperature from $t=0$ at its outer surface to $t=t_1$ at its inner surface, the depth or thickness of it is

$$D \propto \frac{\sigma R^2}{M}.$$

Thus the thickness of the layer is greater with stuff like Hydrogen than with Oxygen. As we really know nothing about how the total radiation from such a layer depends upon the thickness, I cannot use this in my calculations. It is however worth noting that from equal surface areas of layers all with the same range of temperature but of different depths or thicknesses D, the radiation per second $\propto \left(\frac{M}{D}\right)^{n/2}$.

Thus in the case above, in assuming $n=2$, we are really assuming that the radiation from unit area of layer is inversely proportional to its thickness.

Suppose we speak of the depth D′ below the surface to reach a layer of a particular density $\rho_1$ then

$$D' \propto \frac{R^{2\frac{1}{2}}}{M^{\frac{1}{2}}}$$

the depth being independent of whether the stuff is Oxygen or Hydrogen.

### *Stars in General.*

I suppose that many people will think the above speculation to be fairly safe. It is correct on the assumptions. One may apply it to any star until the central density approaches 0·1 or one-tenth of that of water or even more. In the case of our sun, the theory may have been applicable from the time when his radius was twenty times what it is now until it was five times what it is now. Near the surface I assume the density and temperature to be very small, and probably there is no substance that will behave as a perfect gas near the zero of temperature even if its density is also nearly zero. But as the mass of stuff in this condition is small, we may, I think, use our hypothesis. Besides, we are neglecting more important things; many possible conditions difficult to specify; heterogeneity; violent convective rushing of stuff like iron vapour to the places of low temperature where it may undergo sudden condensation and fall as iron hail over large regions; also, intense electrical actions are certainly taking place. All this may be said to be superficial, affecting only a small portion of the whole mass. On the whole, then, we may take our theory of gaseous stars to be applicable to some portion of the life of any star.

I am on much less safe ground when I try to trace the history of a star after its material ceases to behave as a perfect gas, and yet, as I take it, this is very much the longest part of its career. I may only vaguely speculate on its long or short life as a nebula; as a confused mass of streams of meteors in which every collision generates gaseous masses at all kinds of temperatures; its record is fairly clear from the time [if there ever is such a period in the truly gaseous state] when it assumes the spherical shape [in all cases I am neglecting rotation] and gets hotter and hotter and smaller and smaller. If the law of radiation is the same in any star as in our sun, and if we take one year's loss of heat energy by our sun as the unit of energy; if our unit of mass is the mass of our sun and if the sun's present radius is our unit of length, I

find[1] [using Lord Kelvin's popular lecture figures for the present solar radiation] for any star,

$$W = 36 \times 10^6 \frac{M^2}{R} \quad \ldots \ldots \ldots \quad (21)$$

$$h = 32{\cdot}4 \times 10^6 \frac{M^2}{R} \quad \ldots \ldots \ldots \quad (22)$$

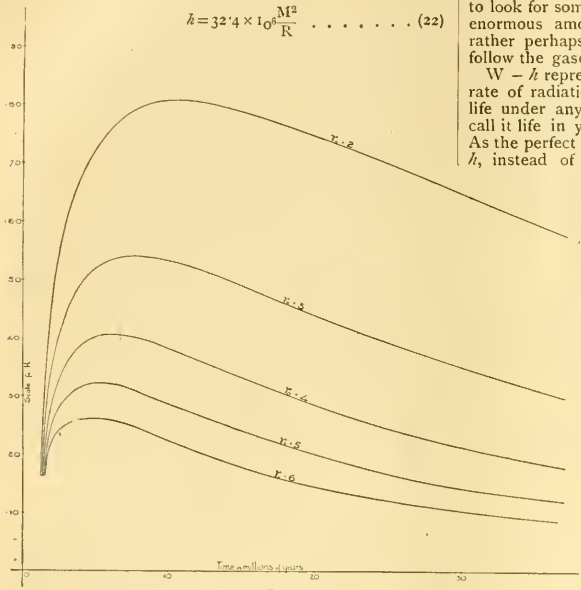


FIG. 1.

I must say that when Mr. Lister first worked out this value of $h$ for me I was greatly surprised, for it has been generally thought that $h$ is always, not merely much less than W, but exceedingly less. But there can be no doubt (see also my final statement) that in a gaseous star the intrinsic or thermodynamic energy in the star is a very large fraction of the whole energy of the gravitating matter. Indeed it is so large that one is tempted to look for some greater original store to account for the enormous amount of radiation which takes place, or rather perhaps to assume that no radiating mass can follow the gaseous law.

W − $h$ represents life in years if we assume a uniform rate of radiation. It has an obvious connection with life under any assumption that we may make. Let us call it life in years, and continue to consider our sun. As the perfect gas law ceased more and more to be true, $h$, instead of increasing steadily, reached a limiting value and then diminished again, so that eventually $h$ must become zero. In what state is our sun now? Is it still very much like a gas throughout, and getting hotter? It is too much to assume for stuff that would be 50 per cent. greater in density than platinum at the centre. In all probability the change from the law of (22) began before R was 5, was quite marked when R was 4, and $h$ reached its maximum value when R was 4 or $3\frac{1}{2}$ or 3. It is quite certain that $h$ must reach a maximum value in any star, and afterwards diminish gradually, and the simplest mathematical formula expressing this fact may be used instead of (22) to give us useful suggestions in regard to the history of our sun. Such a simple formula is

$$h = 0{\cdot}9W \Big/ \left(1 + \frac{R_0^2}{R^2}\right) \quad \ldots \ldots \quad (23)$$

If R is very great (23) is the same as (22). When R is $R_0$, $h$ reaches a maximum value, and for smaller values of R, $h$ diminishes. The following tables have been calculated, a different assumption being made for each. W is calculated from (21). $R_0$ is the radius of our sun (as compared with its present radius) when $h$ was a maximum. Thus the table headed $R_0 = 4$ gives W and $h$, T and D on the assumption that our sun reached its hottest condition when it was of 4 times its present radius. I take $W - h$ and call it T the age or Time in years, but all these values of T may be multiplied by some constant, W, $h$ and T are given in millions.

D is the depth (from surface) of a layer of stuff, say 10,000° C., taking the depth of such a layer at present as 1.

Fig. 1 shows how the intrinsic heat energy of our sun

TABLE II.—*Based on five different assumptions as to the time when our Sun was at its hottest. Also assuming Radiation at present rate.*

| Age of Star in millions of years. | $R_0=6$ | | | | $R_0=5$ | | | | $R_0=4$ | | | | $R_0=3$ | | | | $R_0=2$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T | W | $h$ | R | D | W | $h$ | R | D | W | $h$ | R | D | W | $h$ | R | D | W | $h$ | R | D |
| 0·4 | 3·15 | 2·75 | 11·42 | 129·9 | 2·50 | 2·10 | 14·39 | 208·3 | 2·20 | 1·80 | 16·34 | 270·3 | 2·52 | 2·12 | 14·29 | 204·1 | 3·20 | 2·80 | 12·87 | 166·7 |
| 0·8 | 2·93 | 2·13 | 12·27 | 149·3 | 3·28 | 2·48 | 10·96 | 120·5 | 3·53 | 2·73 | 10·20 | 104·2 | 4·12 | 3·32 | 8·802 | 76·34 | 5·68 | 4·48 | 6·398 | 40·16 |
| 1·5 | 3·94 | 2·44 | 9·229 | 83·33 | 4·30 | 2·80 | 8·433 | 69·93 | 4·82 | 3·32 | 7·568 | 55·87 | 5·65 | 4·15 | 6·448 | 40·65 | 7·01 | 5·51 | 5·173 | 26·39 |
| 2·0 | 4·52 | 2·52 | 8·038 | 63·69 | 4·96 | 2·96 | 7·337 | 52·91 | 5·57 | 3·57 | 6·519 | 42·02 | 6·50 | 4·50 | 5·573 | 30·77 | 8·01 | 6·01 | 4·515 | 20·20 |
| 3·0 | 5·59 | 2·59 | 6·460 | 41·49 | 6·14 | 3·14 | 5·898 | 34·36 | 6·85 | 3·85 | 5·268 | 27·62 | 7·94 | 4·94 | 4·454 | 19·69 | 9·78 | 6·78 | 3·699 | 13·55 |
| 4·0 | 6·61 | 2·61 | 5·476 | 29·67 | 7·23 | 3·23 | 4·975 | 24·81 | 8·01 | 4·01 | 4·515 | 20·20 | 9·19 | 5·19 | 3·927 | 15·38 | 11·28 | 7·28 | 3·198 | 10·19 |
| 5·0 | 7·60 | 2·60 | 4·739 | 22·47 | 8·23 | 3·23 | 4·367 | 19·16 | 9·06 | 4·06 | 3·992 | 15·80 | 10·33 | 5·33 | 3·508 | 12·15 | 12·61 | 7·61 | 2·859 | 8·242 |
| 6·0 | 8·53 | 2·53 | 4·219 | 17·79 | 9·14 | 3·14 | 3·937 | 15·53 | 10·03 | 4·03 | 3·584 | 12·89 | 11·49 | 5·49 | 3·137 | 9·946 | 13·83 | 7·83 | 2·605 | 6·832 |
| 8·0 | 10·33 | 2·33 | 3·484 | 12·15 | 10·54 | 2·54 | 3·413 | 11·67 | 11·91 | 3·91 | 3·021 | 9·219 | 13·37 | 5·37 | 2·698 | 7·246 | 16·07 | 8·07 | 2·244 | 5·072 |
| 12·0 | 13·96 | 1·96 | 2·577 | 6·667 | 14·59 | 2·59 | 2·463 | 6·116 | 15·52 | 3·52 | 2·320 | 5·376 | 17·08 | 5·08 | 2·126 | 4·505 | 20·04 | 8·04 | 1·801 | 3·226 |
| 18·0 | 19·46 | 1·46 | 1·848 | 3·425 | 20·05 | 2·05 | 1·792 | 3·226 | 20·96 | 2·96 | 1·715 | 2·950 | 22·48 | 4·48 | 1·604 | 2·564 | 25·61 | 7·61 | 1·407 | 1·976 |
| 24·0 | 25·22 | 1·22 | 1·427 | 2·037 | 25·68 | 1·68 | 1·401 | 1·961 | 26·44 | 2·44 | 1·362 | 1·855 | 27·93 | 3·93 | 1·291 | 1·667 | 31·04 | 7·04 | 1·160 | 1·346 |
| 34·1 | 34·98 | 0·88 | 1·028 | 1·057 | 35·36 | 1·26 | 1·018 | 1·037 | 35·99 | 1·89 | 1·000 | 1·000 | 37·26 | 3·16 | ·9754 | ·9346 | 40·03 | 6·03 | ·9024 | ·8162 |

[1] In C.G.S. units (13) and (14) give, if the stuff is like oxygen or hydrogen whose $\gamma$ is 1·4,

$$h = 6{\cdot}36 \times 10^{-8} M^2/R,$$
$$W = 7{\cdot}079 \times 10^{-8} M^2/R.$$

In obtaining these numbers Mr. J. Lister took the values of $\theta$ deduced from Mr. Homer Lane's curves before we discovered Lord Kelvin's paper. It will be seen that he gets $h/W = {\cdot}9$. It is easy to show that this ratio must really be 0·83, but I am not concerned in getting mathematical accuracy here. If our $\gamma$ is slightly different from 1·4, we may have the above numbers.

has varied with its age on the above assumptions, which are all uniformitarian. The curves and table will suit any star if the unit of energy employed is the heat radiated per year by the star. If a star is twice the mass of our sun, the unit of energy is four times as great as in the case of our sun. A curve connecting R and time is

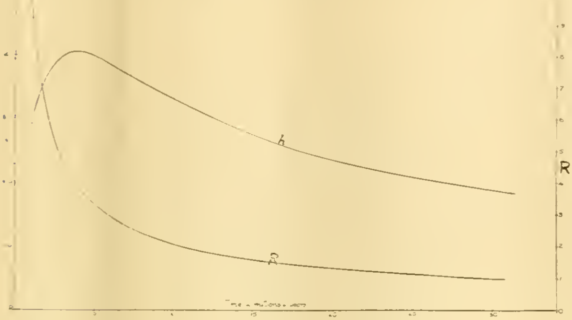


FIG. 2.

the same for all stars, and in the table the sun's present radius is the unit for R.

I take the critical size or size of maximum $h$ in a star to depend upon $\rho_0$ the central density; if then the critical radius of our sun was 4 (or 4 times its present radius), the critical radius of a star whose mass is M times that of our sun was $4\sqrt[3]{M}$.

*Non-Uniformitarian Assumptions.*

The numbers in Table II. enable us to find what any assumption as to rate of radiation leads to. Thus, instead of assuming a constant amount of radiation every year, let us assume in the case of our sun that the rate of radiation at any time was always proportional to $h$. Let us take the supposition that $h$ was greatest for our sun when R was four times its present value. Then as T in the table is no longer to be called time, as it is really $W-h$; let $t$ be time; $c$ being some constant.

$$\delta T = ch.\delta t.$$

Hence

$$t=\int\frac{dT}{ch}.$$

It is quite easy to plot the curve whose ordinate is $\frac{1}{ch}$ and whose abscissa is T of the table; in this way using a value of $c$, which is suitable, I find

TABLE III.—*Rate of Radiation Proportional to* h.

| $W-h$. | $\frac{1}{h}$ | Age in millions of years. $t$. | R. | $h$. |
|---|---|---|---|---|
| 1 | ·342 | 1·0 | 9·18 | 2·92 |
| 2 | ·280 | 1·78 | 6·52 | 3·57 |
| 3 | ·260 | 1·45 | 5·27 | 3·85 |
| 4 | ·250 | 2·09 | 4·51 | 4·01 |
| 5 | ·246 | 2·71 | 3·99 | 4·06 |
| 6 | ·248 | 3·33 | 3·58 | 4·03 |
| 8 | ·256 | 4·58 | 3·02 | 3·91 |
| 12 | ·284 | 7·28 | 2·32 | 3·52 |
| 18 | ·338 | 11·92 | 1·71 | 2·96 |
| 24 | ·410 | 17·53 | 1·36 | 2·44 |
| 34 | ·528 | 29·26 | 1·00 | 1·89 |

The values of $h$ and of R at the various periods in the life of our sun (or any star) are given in Fig. 2.

The curve for $h$ shows also the rate of radiation. It is assumed to have once been more than twice as great as at present in our sun.

Any other assumption may be tried easily. I myself prefer to think that as a star gets older and as its white light radiating layer gets nearer and nearer its outer surface, its rate of radiation increases. It is quite possible as I have shown in NATURE (p. 582, April 1895), that our sun radiated very little energy during long periods in the past. Without taking an extreme case I will assume that the rate of radiation gets greater just in proportion to age and so find the following table.

TABLE IV.—*Rate of Radiation Proportional to Age of Star.*

| $W-h$. | Age in millions of years. $t$. | R. |
|---|---|---|
| 0·4 | 7·95 | 16·34 |
| ·8 | 11·26 | 10·2 |
| 1·5 | 15·42 | 7·57 |
| 2·0 | 17·8 | 6·52 |
| 3·0 | 21·8 | 5·27 |
| 4·0 | 25·2 | 4·51 |
| 5·0 | 28·1 | 3·99 |
| 6·0 | 30·8 | 3·58 |
| 8·0 | 35·6 | 3·02 |
| 12·0 | 43·6 | 2·32 |
| 18·0 | 53·4 | 1·71 |
| 24·0 | 61·7 | 1·36 |
| 34·0 | 73·4 | 1·00 |

The values of $h$ and of R at the various periods in the life of our sun are given in Fig. 3.

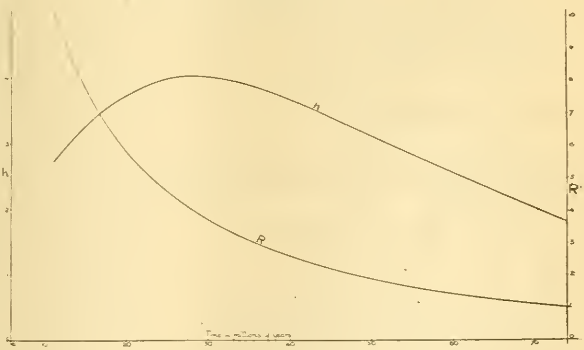


FIG. 3.

On no one of the above assumptions can I see that it is possible to give even a probable limit to the future life of our sun as a light-giving body.

*Energy in a Spherical Mass of Gas.*

I end this long letter with a very curious statement concerning gaseous masses in space, and I am sorry that my own proper work is demanding so much of my attention that I must leave the following very definite statement without applying it, as I see that it may be applied, to the study of the physical properties of many gases. We have seen that, under convective equilibrium, there is an outside radius beyond which there is no stuff

existing. The following statement does not assume convective equilibrium; an outside radius, R, is assumed to exist.

Let temperature, pressure, &c., be functions of $r$. If $m$ is the total mass bounded by the spherical surface of radius $r$,

$$\frac{dp}{dr} = -a\frac{m}{r^2}\rho \quad . \quad . \quad . \quad . \quad . \quad . \quad (24)$$

$$m = 4\pi\int_0^r r^2\rho \,.\, dr \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (25)$$

the stuff being a perfect gas,

$$\rho\sigma t = p \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (26)$$

If $k$ is the specific heat (in ergs) at constant volume, the total intrinsic energy of the mass is

$$h = 4\pi k\int_0^R r^2\rho t \,.\, dr,$$

$$h = \frac{4\pi k}{\sigma}\int_0^R pr^2 \,.\, dr \quad . \quad . \quad . \quad . \quad . \quad . \quad (27)$$

The work that would have to be done in taking successive layers to an infinite distance is

$$W = +a\int_0^R \frac{m}{r}4\pi r^2 \,.\, dr \,.\, \rho = +4\pi a\int_0^R \rho mr \,.\, dr \quad . \quad (28)$$

Now (24) is

$$\rho am = -r^2\frac{dp}{dr},$$

so that

$$W = -4\pi\int_0^R r^3\frac{dp}{dr} \,.\, dr = -4\pi\int_{p_0}^0 r^3 dp \quad . \quad . \quad (29)$$

Now in (27)

$$\int_0^R pr^2 . dr = \Big[\tfrac{1}{3}pr^3\Big]_0^R - \int_{p_0}^0 \frac{r^3}{3}dp.$$

The bracket term is 0, as $r$ is 0 at the centre, and $p = 0$ at the surface. Hence 27 is

$$h = -\frac{4\pi k}{\sigma}\int_{p_0}^0 \frac{r^3}{3}dp.$$

Dividing by (29) we have

$$\frac{h}{W} = \frac{k}{3\sigma}$$

Now in gases, if K is specific heat at constant pressure $\sigma = K - k$ so that

$$\frac{h}{W} = \frac{k}{3(K-k)} = \frac{1}{3(\gamma - 1)}$$

If

$$\gamma = 1\tfrac{1}{3}, \; h = W$$

If

$$\gamma = 1\cdot4, \; h = \cdot833W$$

Here are very definite astonishing statements!

I must confess that I do not understand how if $\gamma = 1\frac{1}{3}$ we can have $h = W$. It seems to mean that if a mass of this kind of gas gravitates by itself from an infinite distance it retains all its energy. But such gas must surely be imagined to be radiating heat, as it is not at zero temperature. Where can it get such heat? I come to the conclusion that there must be atomic energy available somehow in it, even when we imagine the molecules at an infinite distance from one another, or else there is no such gas possible. *I say* that no substance for which $\gamma = 1\frac{1}{3}$ can behave as a perfect gas.

You will notice that we do not need to imagine our stuff in a state of infinite diffusion. If a gaseous star changes its size or the arrangement of its stuff, the gravitational work done is exactly equal to the additional intrinsic heat energy in the star if $\gamma$ is $1\frac{1}{3}$. The paradox is greater if we think of coloured diatomic gases such as chlorine, which have values of $\gamma$ less than $1\frac{1}{3}$. We must either assume that there is more energy available than mere gravitational energy, or else that such substances cannot really behave as perfect gases. [It is to be remembered that by a perfect gas I do not merely mean that $p/t\rho$ is constant, but that $k$, the specific heat at constant volume is constant, a statement which does not follow from the first.] It is some time since I have come across a statement which looks better worth study than this one.

## *WILLIAM HENRY FLOWER, K.C.B., F.R.C.S., LL.D., D.C.L., Sc.D., F.R.S., F.Z.S., F.L.S.*

THE distinguished naturalist whose death has recently occurred was the second son of the late Mr. Edward Fordham Flower, the founder of the well-known brewery at Stratford-on-Avon, and dear to all lovers of animals on account of his crusade against the bearing-rein. Sir William Flower was born in November 1831. He was educated at private schools and at University College, London, where he took Sharpey's gold medal in Physiology, and Grant's silver medal in Zoology. He became M.B. of the University of London in 1851, and joined the Medical Department of the Army in 1854, serving in the Crimea, where his health broke down. On his return to England he became Demonstrator of Anatomy at the Middlesex Hospital, and Curator of the Museum, intending to practise as a surgeon. Here he published his first work, "Diagrams of the Nerves of the Human Body," and also wrote in Holmes' "System of Surgery" on "Injuries of the Upper Extremities."

In 1861, at the age of thirty, he was appointed to succeed Queckett as Curator of the Hunterian Museum at the College of Surgeons, and later became Hunterian Professor. Thenceforward he abandoned professional work for purely scientific pursuits. Twenty years later, when he received the Royal medal of the Royal Society, the President stated with justice that "it is very largely due to his incessant and well-directed labours that the museum of the Royal College of Surgeons at present contains the most complete, the best ordered, and the most accessible collection of materials for the study of vertebrate structures extant."

Two years later (in 1884), on the resignation of Sir Richard Owen, Prof. Flower was appointed Director of the new Natural History Museum in the Cromwell Road, where he was incessantly occupied with the arrangement and development of the collections until failing health necessitated his resignation, which took effect in October 1898. Unhappily he did not long enjoy the rest and leisure which he had so well earned by a life of unusual industry and devotion to public work.

His services in the cause of knowledge were recognised by many honorary degrees from Universities, and by his election as a Correspondent of the Institute of France. He was made C.B. in 1887, and K.C.B. in 1892, and was President in 1889 of the British Association for the Advancement of Science.

The mere enumeration of the incidents in a man's life does not tell very much about the nature and value of his work. Sir William Flower's chief work was in two directions: firstly, as a director and original artist in museum management; secondly, as an investigator and discoverer in the comparative anatomy of the Mammalia. Besides these two chief lines of work, there were others to which he gave time and care. He was not unheedful of the popular demand for instruction and guidance by lectures. He frequently appeared at the Royal Institution and the London Institution, and always had a weighty and well-considered discourse to deliver. The most original and, from a social point of view, the most important of these was one on "Fashion in Deformity," in which he gave very strong support to those who dis-

approve of tight-lacing, high-heeled shoes, and other monstrosities of clothing. Another way in which Sir William Flower gave voluntarily a large amount of valuable work to the community was as President first of the Anthropological Institute, and then of the Zoological Society—a post which he held until his death. Such services in our scientific societies are given without any remuneration, and they can only be repaid by the grateful acknowledgment of those interested in the progress of the branches of science thus benefited.

To revert to the two chief lines of Sir William Flower's life-work. He first became generally known in the scientific world by joining the band of young anatomists who supported Huxley in his rejection of the statements made by Owen as to the differences between the brain of man and of apes. Like the other members of that group—Turner, Humphrey, and Rolleston—Flower published an important contribution to the controversy. This memoir, entitled "Observations on the Posterior Lobes of the Quadrumana," was printed in the *Philosophical Transactions* in 1862; and about the same time Flower wrote also on "the brain of the Siamang" in the *Natural History Review*. His most numerous contributions to anatomical science relate to the Cetacea, which was his favourite group. After the deaths of P. J. Van Beneden and Gervais, he was only rivalled in his knowledge of whales by Sir William Turner, of Edinburgh. It was a special satisfaction to Flower to have been able to complete the admirable exhibition of whales at the Natural History Museum before his retirement—an exhibition which is not only unequalled, but is not even attempted in any other museum in Europe or America. Next to the Cetacea, the subject on which Flower worked and wrote most was physical anthropology. His catalogue of the anthropological series in the museum of the Royal College of Surgeons and its introductory chapter have served as classics to English anthropologists, and are the result of an immense amount of patient research. Separate papers by him on the osteology of the Andaman Islanders and of the Fijians are of great value on account of the large amount of material dealt with, and the caution and judgment shown in drawing conclusions. Caution and reticence in generalisation certainly distinguish all Flower's scientific writings. Whilst he was on this account necessarily not known as the author of stirring hypotheses, his statement of fact gained in weight by his reputation for judgment and accuracy. The most important discovery in anatomical science which we owe to him is that of the existence of but one successional molar in the marsupial Mammals. This sharply defined and important fact was only one, but the most striking, of the results of a long, conscientious and painstaking study of the dentition of the Mammalia. The next most striking discovery which we owe to Flower seems to me to be the complete and convincing demonstration that the extinct marsupial called *Thylacoleo carnifex* by Owen was not a carnivor, but a gnawing herbivorous creature like the marsupial rats and the wombat—a demonstration which has been brought home to the eye even of the unlearned by the complete restoration of the skull of Thylacoleo in the Natural History Museum prepared by Dr. Henry Woodward. Another thoroughly original and elaborate piece of work which should, I think, be especially remembered in attempting to survey Flower's anatomical labours, is the attempt to bring order and system into the study of the forms presented by the lobes of the liver in the Mammalia, an effort which has not, perhaps, as yet borne all the fruit of which it is capable.

In such a brief notice as the present a complete bibliography of Sir William Flower's contributions to anatomical science cannot be given, but a fair notion of his great activity in research can be obtained from a selected list. Relating to the Cetacea, I would cite the following papers from the *Proceedings* of the Zoological Society:—On a lesser Fin-whale (Balænoptera rostrata) stranded on the Norfolk Coast (1864); the skeletons of Whales in the Principal Museums of Holland and Belgium (1864); on a new species of Grampus from Tasmania (1864); on Physalus Sibbaldii (1865); on Pseudorca meridionalis, 1865; on a Fin-whale stranded in Pevensey Bay (1865); the probable identity of Balænoptera Carolinæ and Physalus Sibbaldii (1868); on the Whales of the genus Hyperoodon (1882); on the Characters and Divisions of the Family Delphinidæ (1883); then in the *Transactions* of the same Society, the fine illustrated papers on the skeleton of Inia Geoffrensis (1869); on the osteology of the Cachalot (1869); on the skeleton of a Chinese White Dolphin (1872); on Risso's Dolphin (1873); on recent Ziphioid Whales (1878); on two species of British Dolphins (1880); and the translation of and introduction to Eschricht's treatise published by the Ray Society. Also in the *Proceedings* of the Royal Institution, Whales Past and Present, and their probable origin (1883).

Relating to physical anthropology, Sir William Flower's most important works are the following:—The Catalogue of Specimens in the Museum of the Royal College of Surgeons, 1879 and 1884 (already referred to above), in the *Journal* of the Anthropological Institute; the osteology of the natives of the Andaman Islands (1879); the osteology of the Fijians (1880); the osteology of the Mallicolese (1881); the aims and prospects of the Study of Anthropology (1884); the Classification of the Varieties of the Human Species (1885); on the size of Teeth as a character of Race (1886); in the *Proceedings* of the Royal Institution (a Friday evening discourse) on the Native Races of the Pacific (1878); and in the Manchester Science Lectures, a discourse on the aborigines of Tasmania (1866).

Ranging over other groups of Mammals, I would cite the following papers:—On a newly-discovered extinct Mammal (Homalodontotherium) from Patagonia (*Phil. Trans.*, 1873); Description of the skull of a species of Halitherium from the Red Crag of Suffolk (*Quart. Journ. Geol. Soc.*, 1874); on the remains of Hyænarctos in the Red Crag of Suffolk (*ibid.*, 1877). From the *Proceedings* of the Zoological Society: papers on the anatomy of Galago (1862); of Pithecia monachus (1862); on the brain of the Echidna (1864), on the brain of the Red Howling Monkey (1864); on the anatomy of Hyomoschus (1867); on the development of the teeth in the Armadilloes (1868); on the characters of the base of the cranium and the classification of the order Carnivora (1869); on the anatomy of Proteles cristatus (1869); and on that of Aelurus fulgens (1870); and of the two-spotted Paradoxure (1872); and of the Musk Deer (1875); on the cranial and dental characters of the existing species of Rhinoceros (1876); and on the mutual affinities of the animals composing the order Edentata (1882).

Of a more general character are his articles in the "Encyclopædia Britannica":—On the anatomy and zoology of the Horse, Kangaroo, Lemur, Lion, Mammalia, Mastodon, Megatherium, Otter, Platypus, Rhinoceros, Seal, Swine, Tapir, &c. These have formed the basis of a very useful volume on the Mammalia published by Messrs. Black, whilst the compact little volume on the osteology of the Mammalia by Sir William Flower is known to all University students. The last volume which came from his pen is one of the best and most interesting, namely that called "The Horse: a study in natural history," published in 1892.

Having thus indicated (and only "indicated" by no means "enumerated" or "fully set down") the labours of Sir William Flower in anatomical research, I pass to a brief consideration of his work as a museum curator, which probably took up more of his time and energy than he was able to give to original investigations. This

is most certainly true of the second portion of his scientific life, which dates from his appointment in 1884 to the directorship of the Natural History Museum, and was preceded by twenty years of work as Hunterian Curator. There can be no doubt in the mind of any man who is acquainted with the present condition of the public galleries of the great museums of natural history in Europe, and with the condition which characterised those of similar institutions in Great Britain previously to the year 1864, that a very great and important change for the better was effected by Flower, first of all at the College of Surgeons, and later in accordance with a further development of his ideas, at the Natural History Museum (British Museum, Natural History). The arrangement and exhibition of specimens designed and carried out by Flower in both instances was so definite an improvement on previous methods, that he deserves to be considered as an originator and inventor in museum-work. His methods have not only met with general approval, and their application with admiration, but they have been largely adopted and copied by other curators and directors of public museums both at home and abroad. In his address as President of the British Association, and also in an address to the Museums Association, Sir William Flower has explained in some detail the theory which he held with regard to the proper selection and arrangement of objects in a public museum. The general conception which Sir William Flower had formed was accepted and developed in detail by that gifted and genial museum-director, Brown Goode, of Washington, U.S.

It is simple enough and convincing. But the work of the museum curator consists not merely in framing theories of museum organisation and arrangement: the more important part of his work is the putting of such theories into practice. To do this, energy and patience in the surmounting of obstacles are necessary, and perhaps as much as or more than any other quality—the artistic sense. Sir William Flower possessed this last quality in a remarkable degree. No pains were spared by him in selecting the proper colour for the background or supports of the specimens exhibited in a case, or in effectively spacing and balancing the objects brought together in one field of view. He took the greatest pains to make the museum under his care a delight to the eye, so that the visitor should be charmed by the harmony and fitness of the groups presented to his notice, and thus the more easily led to an appreciation of the scientific lesson which each object has to tell. There are public galleries in some of the natural history museums of Europe where the specimens are so crowded and ill-placed, where the lighting is so badly designed and the prevailing colour of case and wall so depressing, that the main purpose of the exhibition is defeated by the fact that the visitor becomes seriously attacked by headache before he has been able to ascertain what there is for him to look at, or why he should look at anything at all, in the appalling accumulation spread before him. It was Sir William Flower's merit to have introduced a better way, and so far as opportunity and the brief fourteen years of his directorship allowed him to do so, he put that better way into practice at the national museum of natural history. The first great principle upon which Sir William Flower insisted was that the possessions of a great museum of natural history must be divided into two distinct parts—to be separately dealt with in almost all respects—viz. the public or show-collection, and the special or study-collection, not exhibited to the general public, but readily accessible to all investigators and specially qualified persons. The latter collection, he insisted, should have at least as much space devoted to it as the former. In this way the public galleries would (he showed) be cleared of the excess of specimens which, nevertheless, the museum must carefully preserve for the use of specialists. Then, further, Flower held that every specimen placed in the public or show-collection should be there in order to demonstrate to the visitor some definite fact or facts, and so should be most fully visible, isolated rather than obscured by neighbouring specimens, and ticketed with an easily-read label stating clearly and simply the reason why it is worth looking at—that is to say, what are its points of interest. He would thus have reduced very much in *number* the specimens commonly exhibited in natural history museums, and have increased the *interest* and *beauty* of each specimen selected for the public eye. Another principle which he often insisted upon—but was not able to put fully into practice owing to long-standing arrangements in the museum over which he presided—was that in the public galleries the skeletons of animals should not be placed in one room and the stuffed skins in another, and the soft parts in a third, and the fossilised remains of extinct allied animals in a fourth more or less remote chamber; but that the visitor should see, side by side, the stuffed or otherwise preserved animal (mammal, bird, reptile, fish, mollusc, insect, worm or polyp) and its skeleton and important parts of its internal structure and the remains of its extinct allies. Thus, there would be, not three or four separate zoological collections for the amazed visitor to traverse and bring into correlation by mental effort, but one only, in which the story of each animal is told as completely as possible in one connected exhibit. It is simply a fact that the "art of arranging museums for the public" is in its infancy, and that it was mainly, if not entirely (so far as natural history is concerned) founded by William Henry Flower. Like other originators, he did not live to see the principles which he advocated fully acted upon, nor did he expect to do so. He knew that time is a necessary element in such developments. But he has left an enduring mark on what we may call "museum policy." His teaching and performance are producing, and will continue to produce, progress towards the realisation of his ideals.

Sir William Flower did not train or produce any pupils. He did his own work with his own hands, and I have the best reason to know that he was so deeply shocked and distressed by the inaccuracy which unfortunately crept into some of the work of his distinguished predecessor Owen, through the employment of dissectors and draftsmen whose work he did not sufficiently supervise, that he himself determined to be exceptionally careful and accurate in his own records and notes. In later years, he had the assistance of young anatomists in making the beautiful preparations which are placed in the central hall of the museum. One of his assistants, Mr. Wray, whilst preparing, under Sir William Flower's direction, specimens for the museum to exhibit the disposition of the feathers in the wings of birds, discovered the strange and puzzling fact that the fifth cubital quill is apparently absent—that is to say, there is a gap where it should be—in whole orders and families of birds, whilst it is present in other orders and families. The discovery of the wide-spread occurrence of aquintocubitalism—as it has been called—was thus made in Sir William Flower's work-room, and in connection with his scheme of museum exhibition.

It is well to place on record that Sir William Flower was a convinced Darwinian. At the meeting of the Church Congress at Reading in October 1883, he had the courage to open a discussion on "Recent Advances in Natural Science in their relation to the Christian Faith," his expressed object being to mitigate the prejudices of many of the strongest opponents of the doctrine of evolution amongst the clergy.

Whilst discharging in so many different ways important public duties, and holding up amongst scientific men a high standard of accurate work and unremitting devotion

to the progress of zoological knowledge, Sir William Flower found time to extend very largely among the educated classes an interest in the aims and results of zoology by the willing courtesy with which he received visitors at the Museum in Cromwell Road, and explained its contents. His interest in his work there was so sincere that no zoologist ever asked in vain for his help and advice in museum matters. He was so earnest in carrying out his new devices for the effective exhibition to the public of zoological specimens that even on his busiest days he would find a few minutes to show his latest improvements to one who sympathised with his aims and believed in his methods.

Personally, I owe very much to him in this way. I am glad also to be able to acknowledge here the help which he gave to me by supporting in a valuable letter, which was printed and circulated at the time, the re-arrangement of the zoological and anatomical collections in the University Museum at Oxford, which I had proposed and was enabled subsequently to carry out—largely in consequence of the weighty opinion which Sir William Flower gave in its favour. E. RAY LANKESTER.

## THE DUTIES OF PROVINCIAL PROFESSORS.

DURING the past twenty years numerous centres of university education have grown up all over our country, and much public money has been spent in their endowment. Some of these colleges have already risen to the rank of universities with the power of conferring degrees; others are eagerly pressing forward in the same direction in the hope of competing with their more fortunate rivals. If this multiplication of universities is not to result in lowering the prestige of British university degrees, but to enable us to compete in the matter of scientific education with foreign countries, it is of the utmost importance that the professorial staffs of our younger university colleges should be placed under the most favourable positions for establishing the reputations both of themselves and of their colleges in the matter of higher study and research. The time appears to have come when we must face much more boldly than hitherto the question whether the conditions attaching to provincial professorships and lectureships, even in some of our most successful university colleges, are conducive or inimical to progress in such respects.

In calling attention to the serious and, to our mind, unnecessary disadvantages under which provincial professors are often placed at the hands of their Councils or Governing Boards, our remarks must be understood to be based on a considerable number of experiences of which we have gathered details during some years.

A foreign professor may only lecture five hours a week, and devote the rest of his time to research, and yet be regarded as discharging his duties fully and efficiently. Under such a system German professors have filled their class-rooms with the best students drawn from all parts of the world, German degrees are rising in public estimation year by year, English students are going out of their own country for the higher training they cannot obtain at home, and we are mainly indebted to Germany for our standard literature on every branch of science.

In America university development is more recent, but the majority of universities are lavishly staffed with professors and assistant lecturers, who thus have ample time for research; and the system has been introduced of giving these teachers one free year in seven, in order that they may be able the better to keep themselves abreast with the most recent developments of their science. Under such conditions, America is rapidly pressing forward in scientific research, and American text-books are slowly and surely finding their way into English class-rooms.

As instances of what one university can do in promoting research, even in a single department of science, we need only call attention to the *Communications* from the Physical Laboratory of the University of Leiden, published periodically in English, or the *Physical Review*, brought out under the auspices of Cornell University.

Our modern centres of university education are largely bound down to the policy of attracting the greatest number of students, not by the reputations of their professors, but by the attractions they offer in small bursaries and in facilities for cheaply acquiring pass degrees. Under this system a professor may give fifteen lectures a week or more, and spend most of the rest of the day in the laboratory; but there is no limit to the extraneous work required of him by his Council or Governing Board, beyond that research work forms no part whatever of his obligations. We do not deny that good work is done in this country by many provincial professors, but it is often done under extreme difficulties, and many others are debarred from taking that place in the scientific world for which their abilities qualify them.

With regard to the lectures themselves, these are almost exclusively limited by the syllabus of examinations for pass degrees. Matriculation preparation forms a heavy item in the work of most departments, and one to which great importance is commonly attached. It is the duty of the professor not so much to push forward his best students as to adapt his lectures to the requirements of the average student, and to bring as many as possible up to pass standard. He is held responsible for the attendance and diligence of his students in class, and is bound to make records of these matters; while out of class he and his colleagues are jointly responsible for general discipline, even extending to the rules of athletic clubs. He is required to set and correct exercises and examination papers at frequent intervals. If students have not followed his lectures properly he is expected, often at short notice, to provide tutorial instruction without limit to those whose chances of passing are in danger—an arrangement, by the way, hardly calculated to ensure students giving their best attention to professorial lectures.

We do not imagine that any professor, if left to himself, would be wanting in willingness to give a large amount of his private time to helping students over difficulties, and making his lectures convey the greatest amount of instruction with the least amount of work. But if a professor makes a conscientious stand against cramming, or puts any personality into his professorial work, he runs the serious risk of losing at a few weeks' notice the post he has held for years, at the hands of a Governing Board who misinterpret his action because they have no knowledge of the conditions attaching to a sound teaching of his subject. In such cases students, who are more concerned about getting a degree than about the thoroughness of their training, may be called on to give evidence against their professor. We have knowledge of several instances in which colleges have on insufficient grounds lost the services of men who have been doing good work for them, whose teaching has been acknowledged to be successful, and who, under less disadvantageous conditions, would have done them credit by their scientific work.

The practical result of this system is that our modern university centres, whether chartered or not, are devoting their endowments to competing for cheap pass degrees with one another, and with private institutions and tutors who prepare for London University and similar examinations. The students spend the whole day in class-rooms and in laboratories, and when they have done the exercise work required by their teachers, the day is gone and they are too tired to *think over* what they have learnt. Their professors are thus required to do the thinking for them.

After three years in the mill the students obtain a degree, gained under conditions calculated to minimise what should be one of the most important features in any university training: the learning to think and overcome difficulties for oneself. There is thus a growing annual output of graduates of both sexes who find, often too late, that their qualifications only fit them for one career: that of swelling the ranks of the already overcrowded and underpaid teaching profession. The production of a certain number of schoolmasters is a necessary element in the educational system of every country, but the question is: should this or the advancement of higher learning be the main function of a university endowed with public funds?

Many provincial colleges plead poverty as an excuse for overburdening their staffs with pedagogic and tutorial work. But these colleges are not too poor to vie with each other in the award of small scholarships, many of which go to pass students of no great ability. And experience, both in America and in this country, has shown that if only such objects as endowment of research are prominently brought before public notice, support will not be found wanting.

In conclusion, the directions where reform is most needed include the following:—

(1) Discontinuance of matriculation preparation—work which naturally belongs to the province of schools and crammers.

(2) Recognition of research work rather than tutorial instruction of pass candidates as the main duty of a professor outside his class-room.

(3) Reduction of the hours of class work, both of teachers and students.

(4) Revision of the now precarious conditions under which provincial appointments are tenable.

(5) Attraction of public attention to the importance of providing facilities for professorial research.

(6) The appointment of more and better paid assistant-lecturers and demonstrators.

(7) A more judicious expenditure of scholarship money, which should be restricted to honours students.

If the new university systems of this country are not, in the course of a few years, to take a subordinate position, and their degrees to sink into disrepute, if, in short, we are not to be left in the lurch by our foreign rivals, it becomes the duty of all who are responsible for the management of our provincial colleges and universities to have their attention aroused to a state of affairs which too often results in their professors being sweated and their students crammed.

## GOVERNMENT GRANT IN AID OF ANTARCTIC EXPLORATION.

THE following letter, referring to a Parliamentary grant in aid of Antarctic exploration, has been received by Lord Lister from H.M. Treasury, and sent to us by the Secretaries of the Royal Society:—

*Treasury Chambers, July* 3, 1899.

MY LORD,—I am directed by the Lords Commissioners of Her Majesty's Treasury to inform you that the First Lord has laid before the Board the memorial signed by your Lordship as President of the Royal Society, by the President of the Royal Geographical Society, and by other distinguished representatives of various branches of science, by which memorial application is made for a Government grant in aid of the expedition now being organised by the Royal Society and the Royal Geographical Society for the exploration of the Antarctic regions. This application has received the careful consideration of Her Majesty's Government, and I am directed to inform you that they are prepared to ask Parliament for grants amounting, in all, to 45,000*l.* towards the expenses of the proposed expedition, provided you are able to assure them that not less than an equal amount will be forthcoming from other sources, so as to enable the scheme to be efficiently carried out.

In making this announcement, I am to call attention to the latter part of the speech of the First Lord to the deputation which waited on him on this subject, as indicating that Her Majesty's Government must not be regarded, in making this promise, as inaugurating a new era of more extensive grants than formerly from the Exchequer in aid of scientific enterprises. Rather, it is to be understood that the very exceptional importance of the present scheme, so strongly represented by the deputation, is being recognised by the promise of a special grant.

At the present time, it is only necessary to add that the applications to Parliament for instalments of the grant will be spread over four years, of which 1900–1901 will be the first.

I am to ask you to be so good as to communicate this decision to the other signatories of the memorial.

I am, My Lord,
(Signed) FRANCIS MOWATT.

LORD LISTER,
President of the Royal Society,
Burlington House.

## NOTES.

THE Paris Academy of Sciences has been authorised to increase its number of national and foreign Correspondants from 100 to 116.

THE *British Medical Journal* announces that Sir John Burdon Sanderson, Bart., and Prof. Michael Foster, K.C.B., will be entertained at dinner by British physiologists on July 20, to congratulate them on the honours recently conferred on them by the Queen. The dinner will take place at the "Star and Garter," Richmond.

THE Volta Centenary Exhibition at Como, described in NATURE of June 22, has been completely destroyed by a fire, attributed to the fusing of some electric wires. Practically all the precious Volta relics were lost in the flames, notwithstanding the precaution taken to preserve the objects by placing them in a receptacle of solid masonry. The only things saved were a sword of honour presented by Napoleon the First to Volta, a picture by Bertini of Volta explaining his battery to Napoleon, a cast of the great electrician's skull, his watch, and a few personal relics. Volta's books and manuscripts, some of which were recently bought by the Italian Government for 100,000 lire, his collection of batteries, the only authentic portrait of Volta, his will, &c., were all destroyed. In spite of the destruction of the Exhibition, the committee has decided that the *fêtes* in honour of Volta shall be continued. The International Congress of Electricians will be held as previously arranged.

PROF. EWART exhibited a number of his zebra hybrids, their dams, sire, and half-brothers and sisters, at the great Agricultural Show recently held in Edinburgh. The authorities were little prepared for the interest taken in the exhibit, with the result that many thousands either failed to see anything of the hybrids, or had but a passing glance. The Prince of Wales, accompanied by a deputation of the Royal Agricultural Society of England, made a special inspection of the mixed family. From a contemporary we learn the Prince was so greatly interested that he requested Prof. Ewart to make a similar exhibition next summer at the Royal Agricultural Societies' Show at York. Should breeders give up empirical in favour of scientific methods, not a

little of the credit will be due to the Prince of Wales recognising the importance of the investigations that have for some years been carried on by the Edinburgh Professor of Natural History.

AN international conference organised by the Royal Horticultural Society for the purpose of discussing "Hybridisation (the cross-breeding of species) and the cross-breeding of varieties" was opened on Tuesday. In opening the proceedings, Dr. Maxwell Masters gave an address on the history of the subject. Papers dealing with the experimental production of plant-hybrids and the scientific significance of the results were read by Mr. W. Bateson, F.R.S., Prof. H. de Vries, Prof. George Henslow, Prof. L. H. Bailey, and Mr. C. C. Hurst.

*Science* announces that Dr. Milton Updegraff, professor of astronomy in Missouri University, has been appointed, by President McKinley, professor of mathematics in the United States Naval Observatory.

WE learn from the Secretary of the Institution of Electrical Engineers that the reunion of the Institution in Switzerland, from September 1 to 10 next, is likely to be well attended, and that the final arrangements for the visit are now in progress. It is hoped that a circular giving further details may be issued at the end of the current month.

To commemorate the services which the late Mr. H. T. Soppitt rendered to mycological science and to Yorkshire natural history generally, efforts are being made to obtain funds to form a Soppitt memorial library of mycological literature, of which the nucleus should be Mr. Soppitt's own books and herbaria, which the widow and family are willing to part with for such a purpose. Such further funds subscribed as are not required for the purchase of these, are to be laid out in the purchase of mycological reference-books. The library when formed will be presented to the Yorkshire Naturalists' Union.

MR. H. H. HOWELL, who joined the Geological Survey under De la Beche in 1850, retires from the service to-day. Mr. Howell, after surveying some portions of Wales and the south of Scotland, and large areas in the midland counties of England, became District Surveyor of the north-eastern counties of England in 1872, he was appointed Director for Scotland in 1882 (when Sir Archibald Geikie became Director General), and he was further promoted to be Director for Great Britain in 1888.

MR. ERNEST E. L. DIXON, who has for the past two years acted as assistant to Prof. Judd at the Royal College of Science, has been appointed an Assistant Geologist on the Geological Survey of England.

THE annual meeting of the Society of Chemical Industry commenced yesterday at Newcastle-upon-Tyne. In his presidential address, Mr. George Beilby dealt with the question of fuel and smoke. The magnitude of this problem may be judged from the fact that the total coal consumed in the United Kingdom in 1898 was 157 million tons, of which 76 million tons were consumed for the production of power for industrial purposes, 46 million for the production of heat for industrial purposes, and 35 million for the production of heat for domestic purposes. The various remedies which have been suggested to reduce this consumption by using coal more economically are (1) improved appliances for the combustion of raw coal, and distribution of the air supply in furnaces; (2) the transformation of the raw coal into smokeless fuel by preliminary treatment, either by destructive distillation in gas retorts or in coke ovens, or by its conversion into fuel gas by partial combustion in air and steam. Mr. Beilby considered these remedies, and concluded by suggesting that, as a means of bringing all of the different interests which are concerned in this matter into line, the Society should arrange for the holding of a conference on the subject of fuel and smoke, at which the leading technical societies, as well as the actual industries concerned, should be fully represented.—Prof. C. F. Chandler, of New York, was elected president of the Society in succession to Mr. Beilby.

THE death is announced of Sir Alexander Armstrong, K.C.B., author of "A personal narrative of the discovery of the North-West passage" (1857) and "Observations on Naval Hygiene, particularly in connection with Polar service," at the age of eighty-one. From the *Times* we learn that in 1849 the deceased was appointed surgeon and naturalist to Her Majesty's ship *Investigator*, under the command of Captain (afterwards Sir Robert) McClure, which sailed from Plymouth on January 20, 1850, for the Polar Sea in search of Sir John Franklin. After encountering many difficulties, the *Investigator*, in September 1851, was forced into a bay which Captain McClure named Mery Bay. Here both officers and men suffered great hardship and privation, the food being reduced during the second winter to two-thirds of its original quantity, and the sickness increasing to a great extent, when they were rescued from their perilous position hy Lieut. Bedford Pim. In the previous April, Captain McClure had taken a party from the ship and, crossing the strait, reached Melville Island, where he left notice in a cairn that the *Investigator* was icebound off Bank's Island. This notice was discovered by a travelling party from Her Majesty's ship *Resolute*, under Captain Kellett, who were stationed off Melville for their winter quarters. It was then that Lieut. Pim volunteered to go in search of the ship, which he reached on April 6, 1853, after a journey of 160 miles, which occupied him twenty-eight days. The *Investigator* was then abandoned, and the officers and crew were transferred to the *Resolute*; but, owing to that vessel being unable to get to the eastward, they were compelled to pass another winter—the fourth—in the ice. Eventually they were transferred to the *North Star*, and reached England on September 28, 1854. By this expedition the existence of a north-west passage was fully established. Sir Alexander Armstrong was appointed Director-General of the Medical Department of the Navy in 1869, and retired from that office in 1880.

AN account of some simple experiments on the best forms of curves for use with gliding or soaring machines for artificial flight has been sent to us by Mr. A. A. Merrill, of the Boston Aeronautical Society, U.S.A. A bicycle wheel was arranged to revolve in a vertical plane upon an axle fastened in a pier. From a point on the wheel a rod projected, and at the end of the rod the surface to be experimented upon was fixed at an observed angle with the plane of revolution of the wheel. The wheel was then started by the fall of a weight joined to the wheel in such a way that when the weight had fallen through a certain distance it became disconnected. After a surface had been fastened to the rod, the wheel was started, and when it had stopped the number of revolutions it had made was shown by a mechanical recorder. Given the same starting force, the number of revolutions would evidently depend upon the facility with which the surface moved through the air. The surface which offered the least resistance to motion was thus obtained. Among other results, the experiments seem to confirm Mr. L. Hargrave's statement that the existence of a wind vortex under a bird's wing is an important factor in soaring.

A SATISFACTORY report of the committee of the Albany Museum, Cape of Good Hope, for the year 1898, has been issued. While special attention has been given to the development of the South African collections, a number of specimens

of general interest have been acquired from foreign countries. Dr. S. Schönland, director of the museum, reports that the kitchen-middens near Port Alfred have again yielded a number of interesting specimens. Amongst them were portions of skulls of some human beings (which still await a careful examination) and a number of animal bones, amongst which was the lower jaw of the Vlakke Vark (*Phacochaerus aethiopicus*). This animal is quite extinct in Cape Colony now, and it was not previously known that it had occurred at all in that neighbourhood. Dr. Schönland has been able to get some light thrown on a question concerning the pottery found in these middens, which has hitherto puzzled many ethnologists. More or less large pieces of pottery, with holes neatly drilled through them, have frequently been found; and the meaning of these holes has hitherto been unexplained. It now appears that these pots with holes were used as miniature kilns, technically known as "saggers" (in which smaller pots were burned), and the need of holes through them becomes obvious when the use of these pots is known.

IN his introductory lecture, Prof. J. A. Thomson, the newly-appointed Regius Professor of Natural History in the University of Aberdeen, gives utterance to a note of warning as to the direction in which our biological studies are tending. "Amid the undoubted and surely legitimate fascinations of dissection and osteology, of section-cutting and histology, of physiological chemistry and physiological physics, of embryology and fossil-hunting, and the like, do we not need to be reminded sometimes that the chief end of our study is a better understanding of living creatures in their natural surroundings?" He even goes so far as to say that it is difficult to see any reason for adding aimlessly to the already overwhelming mass of morphological and systematic detail. And that what we should rather aim at is the understanding of the chief laws of organic architecture, of the certainties and possibilities of blood-relationship among living creatures, and a true conception of what is meant by the term organisation. As has been pointed out elsewhere by Prof. Alfred Newton, such a warning is undoubtedly needed at the present day, when there is far too great a tendency to regard the description of mere structure as the ultimate end of biological research. It is as if some person to whom modern telegraphy were unknown were to describe in great detail the mechanics of the various instruments employed therein without the vaguest conception of their practical use.

THE inexplicable habit of snails occasionally abandoning their shells is again alluded to in the July number of the *Journal of Conchology*. A former instance recorded was that of pond-snails (*Limnea*), but this time it is land-snails (*Helix*) captured at Venice. Here is a case in point illustrative of what is said above—the fact is all very well in its way, but is of no real interest unless we know the reason for such a strange perversity of habit.

THE most generally interesting article in the June number of the *American Naturalist* is one by Prof. Sylvester Judd on the efficiency of some of the protective adaptations of insects in securing their safety from foes. As the conclusions are chiefly based upon the undigested contents of the stomachs of a very large number of birds, it will be obvious that the author has a definite set of facts with which to test the validity of theories—and the facts are by no means always in accord with the theories. Especially is this the case with insects presenting a presumed protective resemblance with the object or ground on which they rest. Grasshoppers, for instance, even when lying still and then most like their surroundings, are snapped up by numbers of birds; as are also the larvæ of "looper" moths which resemble twigs, and likewise weevils. On the other hand, hairs, like those of many caterpillars, and, to a minor extent, the stings of bees and wasps, appear to be much more efficacious for protection. The brilliant colours of lady-birds seem likewise highly protective. "Warning colours" are, however, by no means always effective in this respect; and pungent odours and acid juices (which may be more suited to avian than to human palates) often also fail to save the insects in which they occur.

THE detailed studies that are now being made of the religious ceremonies of various native tribes of North America by trained American anthropologists are worthy of special study by all students of Comparative Religion. It is now possible, as Dr. J. Walter Fewkes points out in his account of "The winter solstice altars at Hano Pueblo" (*American Anthropologist*, n.s., i. p. 251), to trace the effect of one cult upon another in mixed populations. Walpi, for example, commenced as a settlement of Snake clans which had united first with the Bear phratry and subsequently with other phratries of lesser importance. The purport of the winter solstice (*Tuñtai*) rites at Hano is to draw back the sun in its southern declination and to fertilise the corn and other seeds, and to increase all worldly possessions. As at Walpi, strings with attached feathers are made and given to men and women with wishes that the gods may bring them blessings. These strings are also attached to beams of houses, placed in springs of water, tied to tails of horses, burros, sheep, dogs, chickens, and indeed every possession which the Indian has and wishes to increase.

THE experimental psychologists have passed from testing senses to experimenting on sensations, and "The Emotion of Joy" forms the subject of a monograph, by Dr. G. Van Ness Dearborn, in *The Psychological Review*, vol. ii., 1899. The first series of experiments consisted in recording what the subject said he felt like doing, or would probably do under the accession of hypothetical gifts of ten, one hundred, one thousand, ten thousand and one hundred thousand dollars respectively. The more practical experiments consisted in noting unconscious muscular movements during pleasant or unpleasant conditions of sound, light, smell, &c. It was found that somewhat in proportion to its proper pleasantness, an emotional extramotion consists in expansiveness and outwardly in contraction of extensor muscles; this is true of the smile and laugh of joy. Contraction of the extensor muscles is more pleasant in itself than contraction flexors; there is a general tendency to flexion under a (naturally unpleasant) sudden shock.

IN recent years several authors have published expositions of the methods originated by Hansen in dynamical astronomy; the text-books on lunar theory chiefly used in this country—Brown's "Lunar Theory," and the third volume of Tisserand's "Mécanique Céleste"—each devote a chapter to the subject. As the ephemerides of the moon given in the *Nautical Almanac* and the *Connaissance des Temps* are still calculated from Hansen's tables, as corrected by Newcomb, the theory cannot be neglected by astronomers; though in the hopes of mathematicians it has been somewhat displaced by the more fascinating work of living writers. In a memoir (*Ueber die Differentialgleichungen der Mondbewegung*), reprinted from the *Transactions* of the Leipzig Academy, Dr. Scheibner (who we believe is a former pupil of Hansen) develops systematically the numerous and complicated equations which form the basis of Hansen's theory of the moon's motion. The memoir will doubtless be welcome to those German students who have felt the need of something in their own language intermediate in character between the brief account given in Herz's article in the "Handwörterbuch der Astronomie," and Hansen's own exposition in the *Darlegung*.

"SOME Glacial Wash-plains of Southern New England" is the title of an essay by Mr. J. B. Woodworth (*Bulletin* of the

Essex Institute, Salem, vol. xxix.). These "wash-plains" or stream deltas and fans constitute a very important feature in the Pleistocene deposits of the region. They form the lowlands on which the greater number of towns and villages are built. To the early settler, they offered flat ground free from the boulders which are strewn over the uplands; and they yield vast stores of gravel and sand in fairly definite positions. Representing the morainal deposits of a retreating ice-lobe, they comprise the materials spread out at successive stages by streams and rivers which issued from the ice; and these deposits vary according to their original relations to the frozen mass. Hence the coarse gravels and the finest sands may be looked for in particular areas. No definite relations to sea-level are found among the various wash-plains. It is noticed that temporary lakes were at times produced by the local presence of blocks of ice; and it is pointed out that the retreat of the ice from the area was so recent that the general form of the deposits and most of their details remain unaltered. Owing, however, to the decay of some of the basaltic and other stones, the surface of the ground has been somewhat lowered.

HERR A. WEIGEL, of Leipzig, has acquired the last two remaining copies of Kützing's *Tabulae Phycologicae*, in 19 vols., with 1900 coloured plates, which he offers for sale at 2400 m. (Kützing's own copy) and 2000 m. respectively.

MESSRS. DULAU AND CO., of Soho Square, have issued a catalogue of botanical works, consisting entirely of works on Phanerogamia, which are arranged alphabetically in their natural orders. The same firm forwards also a catalogue of books and papers on British botany.

*Bulletin* 168 of the Cornell University Agricultural Experiment Station is devoted to an account, by Prof. G. F. Atkinson, of three species of Fungi which he regards as valuable from an esculent point of view, *Coprinus comatus*, *C. atramentarius*, and *C. micaceus*, with abundant illustratious.

DR. F. SCHLEICHERT has an interesting note, in a recent number of the *Naturwissenschaftliche Wochenschrift* (June 25) on the observation of phenomena of vegetable physiology in the winter. Many of them, especially those connected with the supply of nutrition, may be followed nearly equally well at that period of the year as in summer.

DR. L. O. HOWARD has published an account of the principal insects affecting the tobacco-plant in America in the *Year-book* of the Department of Agriculture for 1898. Although the plant is said to have no enemies peculiar to itself, it suffers from the attacks of many omnivorous *Lepidoptera*, especially Sphinges and Noctuæ; and from those of various *Coleoptera*, *Hemiptera*, &c.

WE have received parts 10-12 (published in 1898) of the second volume of a journal called *Lavoura*, published by the National Society of Agriculture of Brazil. Among the miscellaneous contents which fill the magazine, we find a coloured plate of the imago and pupa of a butterfly (*Heliconius eucrate*, Hübn.); illustrated articles on a formidable internal parasite (*Anchylostoma*), and on the history of the wheat-plant; a portrait of the late Prof. Aimé Girard; notices and figures of *Eleusina coracano* and *indica* (forage-plants); and much agricultural and statistical information, primarily, of course, of local interest.

THE first number of *Le Mois scientifique et industriel*—a monthly synopsis of scientific information—has been received. To some extent, the new periodical resembles *Science Abstracts*, but it contains more abstracts of engineering papers, and less of scientific investigations. The abstracts are concise, comprehensive as regards nationality, and well printed; they should, therefore, be of real service to French readers interested in the progress of pure and applied science.

A CAREFUL investigation of tautomeric compounds, *i.e.* substances which react as though each possessed more than one molecular structure, though only represented by *one* substance, has revealed in a few cases the actual existence of the different structural forms. A very interesting example is furnished by diacetylsuccinic ester, which has lately been studied by Prof. Knorr. At the time of its discovery it was regarded as a single distinct individual, having the formula

$$\begin{array}{ccc} CH_3.CO.CH & . & CH.CO.CH_3 \\ | & & | \\ COOR & & COOR \end{array}.$$

According to Knorr the presence of the other structural isomers has been overlooked from the fact that, though not the most stable relatively, the original compound has the highest melting point, and, being the least soluble, has crystallised most readily from solution. Knorr predicted some time ago the existence of seven isomeric compounds, not including optically active forms, and of these he has already succeeded in preparing five, whilst he considers it very probable that the two missing members will be found. These will be represented by the following formulæ:—

$$\begin{array}{cc} CH_3.CO.CH.COOR & CH_3.C(OH):C.COOR \\ | & | \\ CH_3.CO.CH.COOR & CH_3.C(OH):C.COOR \\ \text{Keto-form} & \text{Enol-form} \\ \text{representing two} & \text{representing three} \\ \text{inactive forms.} & \text{cis-trans-forms.} \end{array}$$

$$\begin{array}{c} CH_3.C(OH):C.COOR \\ | \\ CH_3.CO.CH.COOR \\ \text{Keto-enol-form} \\ \text{representing two} \\ \text{inactive forms.} \end{array}$$

A RECENT issue of the *Transactions* of the Oxford University Junior Scientific Club contains a valuable account, by Mr. A. F. Walden, of the condition of dissolved substances in solutions other than aqueous. The experiments of Carrara have shown that solutions in methyl alcohol exhibit a progressive ionisation, and that the independence of the ions is as clearly marked as in the case of aqueous solutions. Tessarin has also shown that the molecular lowering of the freezing point of formic acid brought about by the chlorides and bromides of the alkali metals is abnormally high, showing that this solvent also behaves like water. Recent experiments by Franklin and Kraus have shown that liquid ammonia acts as a dissociating solvent. In reference to the hypothesis of Nernst that the dissociating influence of a solvent is related to its dielectric capacity, it is to be remarked that the dielectric constants of water, methyl alcohol, acetone, formic acid, and ammonia are all high. It is pointed out also that these solvents, with the possible exception of acetone, are characterised by having "associated" molecules. On the whole, therefore, it may be said that the phenomena which it is attempted to represent by the hypothesis of electrolytic dissociation are not peculiar to aqueous solutions. They are, so far as experimental evidence is available, found to be characteristic of solutions of salts in other solvents possessing high dielectric capacities and complex or associated liquid molecules. According to Thwing, the dielectric capacity is both an additive and a constitutive property. It increases as the temperature is lowered. The factor of association, according to Ramsay and Shields, also increases as the temperature is lowered. These facts have all to be considered in dealing with solutions and in comparing ionisation determinations made by different methods. Thus we have some explanation of the observation that the degree of ionisation of metallic salts dissolved in methyl or ethyl alcohol is uniformly less when estimated by the boiling point method

than when measured by the determination of electrical conductivity at a lower temperature.

THE additions to the Zoological Society's Gardens during the past week include a Macaque Monkey (*Macacus cynomolgus*) from India, presented by Mr. J. H. Higgins; two Maholi Galagos (*Galago maholi*) from South Africa, presented by the Hon. Gilbert Johnstone; two Common Badgers (*Meles taxus*), British, presented by Mr. A. Gorham; a Spring-bok (*Gazella euchore*, ♂), a Ring-hals Snake (*Sepedon haemachates*) from South Africa, four Spur-winged Geese (*Plectropterus gambensis*) from West Africa, presented by Mr. J. E. Matcham; two Lanner Falcons (*Falco lanarius*) European, presented by Sir H. H. Johnston, K.C.B.; a Yellow-fronted Amazon (*Chrysotis ochrocephala*) from Guiana, presented by Mrs. G. F. Cote; a Hunting Crow (*Cissa venatoria*) from India, a Black-necked Grackle (*Graculipica nigricollis*) from China, a Larger Rocket-tailed Drongo (*Dissemurus paradiseus*) from India, a Sacred Kingfisher (*Halcyon sancta*) from Australia, a Black Hangnest (*Cassidix orizivora*) from the Amazons, two Blackbirds (*Turdus merula*), European; a Brown Thrush (*Turdus leucomelas*) from South America, presented by Mr. Russell Humphreys; an Arabian Baboon (*Cynocephalus hamadryas*) from Arabia, three Barbary Partridges (*Caccabis petrosa*) from North Africa, three Western Pintailed Sand-Grouse (*Pterocles pyrenaica*), South European, a Grand Galago (*Galago crassicaudata*) from East Africa, three Black-headed Terrapins (*Damonia reevesi-unicolor*), three Reeve's Terrapins (*Damonia reevesi*) from China, a Home's Cinixys (*Cinixys homeana*), a Derbian Sternothere (*Sternothaerus derbianus*) from West Africa, three Reticulated Pythons (*Python reticulatus*) from the East Indies, deposited; four Crested Pigeons (*Ocyphaps lophotes*) from Australia, an Ostrich (*Struthio camelus*, ♂) from Senegal, a Sun Bittern (*Eurypyga helias*) from South America, a Scarlet Ibis (*Eudocimus ruber*) from Pará, purchased; a Japanese Deer (*Cervus sika*, ♂), born in the Gardens.

## *OUR ASTRONOMICAL COLUMN.*

COMET 1899 *a* (SWIFT).—

*Ephemeris for 12h. Berlin Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ | Br. |
|---|---|---|---|
| July 13 | 14 13 3 | +13 50·7 | 0·06 |
| 15 | 12 26 | 12 59·9 | |
| 17 | 12 1 | 12 12·1 | |
| 19 | 11 45 | 11 26·9 | 0·05 |
| 21 | 11 36 | 10 44·1 | |
| 23 | 11 34 | 10 3·6 | 0·04 |
| 25 | 11 40 | 9 25·1 | |
| 27 | 11 53 | 8 48·3 | |
| 29 | 12 10 | 8 13·3 | 0·03 |
| 31 | 12 32 | 7 39·7 | |
| August 2 | 14 12 59 | + 7 7·6 | |

TEMPEL'S COMET 1899 *c* (1873 II.).

*Ephemeris for 12h. Paris Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ ″ | Br. |
|---|---|---|---|
| July 13 | 20 31 7·6 | −14 25 22 | |
| 14 | 32 20·5 | 14 55 18 | |
| 15 | 33 33·2 | 15 25 46 | 3·418 |
| 16 | 34 45·7 | 15 56 42 | |
| 17 | 35 58·0 | 16 28 5 | |
| 18 | 37 10·2 | 16 59 51 | |
| 19 | 38 22·3 | 17 31 59 | 3·566 |
| 20 | 20 39 34·3 | −18 4 26 | |

The comet is still on the borders of Sagittarius and Capricornus, about 3° west of α and β Capricorni. M. L. Schulhoff points out in *Ast. Nach.* (No. 3574) that it is important to secure as many accurate observations of the comet as possible at observatories of different latitudes during this apparition, as by this means our knowledge of the mass of Jupiter may be considerably improved.

THE NEW ALLEGHENY OBSERVATORY.—A little over a year ago Mr. J. A. Brashear inaugurated a movement to provide for the erection of a new building and an adequate instrumental equipment for the Allegheny Observatory, and the fund, from numerous subscriptions received, has grown to such proportions that the plan shows every sign of success. Prof. F. L. O. Wadsworth, until recently a member of the staff of the Yerkes Observatory, has been appointed to the directorship, and the plans for the new building have been prepared by him. The largest instrument is to be a refracting telescope of 30 inches aperture, with object-glass by Brashear, and special provision is to be made for astrophysical investigations, which will form the principal work of the observatory.

LEEDS ASTRONOMICAL SOCIETY.—The *Journal and Transactions* for the year 1898, lately issued, maintains the excellent standard of former years. Among the many interesting papers mention may be made of "The movements of the moon," "Star temples in Egypt," "Astronomy as applied to navigation." The volume contains two plates, one showing four drawings of Jupiter and one of Saturn made by Mr. H. J. Townshend, and the other a portrait of Mr. T. J. Moore, who has charge of one of the micrometers from the Oxford Observatory, with which he is engaged in measuring the plates for the Astrographic Catalogue. Accompanying this is a very lucid description of the work and scope of the Astrographic Survey, by Mr. Moore.

## *THEORY OF THE MOTION OF THE MOON.*[1]

THE second part of Dr. Brown's "Lunar Theory" contains the calculation of the terms of the third order in the eccentricities, inclination and ratio of the parallaxes. The first part (reviewed in NATURE, November 25, 1897) had already dealt with the general theory, the variation, and the terms of the first and second orders. It will be remembered that the differential equations to be solved are

$$(D+m)^2u+\tfrac{1}{2}m^2u+\tfrac{3}{2}m^2s-\frac{ku}{(us+z^2)^{\frac{3}{2}}}=-\frac{\partial\Omega_1}{\partial s}$$

$$(D-m)^2s+\tfrac{1}{2}m^2s+\tfrac{3}{2}m^2u-\frac{ks}{(us+z^2)^{\frac{3}{2}}}=-\frac{\partial\Omega_1}{\partial u}$$

$$(D^2-m^2)z-\frac{kz}{(us+z^2)^{\frac{3}{2}}}=-\tfrac{1}{2}\frac{\partial\Omega_1}{\partial z}.$$

The notation is sufficiently familiar to render explanation unnecessary.

Dr. Brown's procedure is as follows:—Let

$$u=u_0+u_\mu+u_\lambda,\ z=z_\mu+z_\lambda$$

where $u_0$ denotes the variational terms

$$u_\mu,\ z_\mu$$

the terms of the orders already calculated

$$u_\lambda,\ z_\lambda$$

the terms of the next order to be calculated.

Then expanding by Taylor's theorem the unknown terms enter in the form

$$\zeta^{-1}(D+m)^2u_\lambda+M\zeta^{-1}u_\lambda+N\zeta s_\lambda,$$

and

$$D^2z_\lambda-2Mz_\lambda,$$

M, N being functions of the known variational terms.

The unknown terms enter under the same form every time, but if a solution with indeterminate coefficients be assumed, the coefficients in the simultaneous equations that result will depend upon the period of the inequality under consideration, and therefore, from the point of view of numerical solution, entirely different nearly every time. All who have had the practical

[1] "Theory of the Motion of the Moon; containing a New Calculation of the Expressions for the Coordinates of the Moon in Terms of the Time." By Ernest W. Brown, M.A., Sc.D., F.R.S. (from the *Memoirs* of the Royal Astronomical Society, vol. liii.).

experience know how laborious is the solution of twenty simultaneous equations. Prof. Brown estimates the solution of the equations at half the labour of obtaining them, in addition

| Reference number. | Characteristic. | Argument. | Number of terms. | Approximate value in arc of the largest coefficient. | Value of unity in the last figure given, in millionths of a second of arc. |
|---|---|---|---|---|---|
| | | | | " | |
| 1 | 1 | 0 | 13 | 206265 | 0·0002 |
| 2 | $e$ | $\pm l$ | 18 | 17000 | 2 |
| 3 | $e'$ | $\pm l'$ | 21 | 350 | 0·4 |
| 4 | $a$ | D | 9 | 80 | 0·05 |
| 5 | $k$ | F | 11 | 9000 | 0·01 |
| 6 | $e^2$ | $\pm 2l$ | 21 | 240 | 3 |
| 7 | $e^2$ | 0 | 11 | 340 | 3 |
| 8 | $ee'$ | $\pm(l+l')$ | 21 | 140 | 4 |
| 9 | $ee'$ | $\pm(l-l')$ | 22 | 100 | 4 |
| 10 | $e'^2$ | $\pm 2l'$ | 18 | 6 | 0·6 |
| 11 | $e'^2$ | 0 | 10 | 2 | 0·6 |
| 12 | $k^2$ | $\pm 2$F | 20 | 400 | 0·4 |
| 13 | $k^2$ | 0 | 11 | 400 | 0·4 |
| 14 | $ea$ | D$\pm l$ | 19 | 12 | 0·6 |
| 15 | $e'a$ | D$\pm l'$ | 20 | 14 | 0·1 |
| 16 | $a^2$ | 0 | 9 | 0·01 | 0·1 |
| 17 | $ke$ | F$+l$ | 10 | 15 | 0·06 |
| 18 | $ke$ | F$-l$ | 11 | 45 | 0·06 |
| 19 | $ke'$ | F$+l'$ | 10 | 1 | 0·01 |
| 20 | $ke'$ | F$-l'$ | 11 | 0·4 | 0·01 |
| 21 | $ka$ | D+F | 10 | 4 | 0·02 |
| 22 | $e^3$ | $\pm 3l$ | 17 | 11 | 27 |
| 23 | $e^3$ | $\pm l$ | 18 | 11 | 27 |
| 24 | $e^2e'$ | $\pm(2l+l')$ | 17 | 6 | 4 |
| 25 | $e^2e'$ | $\pm(2l-l')$ | 18 | 3 | 4 |
| 26 | $e^2e'$ | $\pm l'$ | 19 | 8 | 4 |
| 27 | $ee'^2$ | $\pm(l+2l')$ | 16 | 5 | 0·6 |
| 28 | $ee'^2$ | $\pm(l-2l')$ | 15 | 2 | 0·6 |
| 29 | $ee'^2$ | $\pm l$ | 17 | 1 | 0·6 |
| 30 | $e'^3$ | $\pm 3l'$ | 13 | 0·3 | 0·01 |
| 31 | $e'^3$ | $l'$ | 16 | 0·1 | 0·1 |
| 32 | $ek^2$ | $\pm(l+2$F$)$ | 15 | 11 | 4 |
| 33 | $ek^2$ | $\pm(l-2$F$)$ | 17 | 30 | 4 |
| 34 | $ek^2$ | $\pm l$ | 16 | 14 | 0·4 |
| 35 | $e'k^2$ | $\pm(l'+2$F$)$ | 15 | 2 | 0·07 |
| 36 | $e'k^2$ | $\pm(l'-2$F$)$ | 16 | 1 | 0·7 |
| 37 | $e'k^2$ | $\pm l'$ | 16 | 4 | 0·7 |
| 38 | $e^2a$ | D$\pm 2l$ | 18 | 0·8 | 0·6 |
| 39 | $e^2a$ | D | 7 | 1·3 | 6 |
| 40 | $ee'a$ | D$\pm(l+l')$ | 16 | 0·4 | 1 |
| 41 | $ee'a$ | D$\pm(l-l')$ | 16 | 0·8 | 1 |
| 42 | $e'^2a$ | D$\pm 2l'$ | 15 | 0·3 | 0·02 |
| 43 | $e'^2a$ | D | 8 | 0·4 | 0·2 |
| 44 | $k^2a$ | D$\pm 2$F | 16 | 0·5 | 0·1 |
| 45 | $k^2a$ | D | 8 | 3 | 0·1 |
| 46 | $ea^2$ | $\pm l$ | 16 | 0·03 | 0·1 |
| 47 | $e'a^2$ | $\pm l'$ | 16 | 0·002 | 0·02 |
| 48 | $a^3$ | D | 8 | 0·001 | 0·03 |
| 49 | $k^3$ | 3F | 9 | 1 | 0·2 |
| 50 | $k^3$ | F | 8 | 0·2 | 0·2 |
| 51 | $ke^2$ | F$+2l$ | 10 | 10 | 1 |
| 52 | $ke^2$ | F$-2l$ | 10 | 9 | 1 |
| 53 | $ke^2$ | F | 10 | 4 | 1 |
| 54 | $kee'$ | F$+l+l'$ | 10 | 5 | 0·2 |
| 55 | $kee'$ | F$-l-l'$ | 10 | 3 | 0·2 |
| 56 | $kee'$ | F$+l-l'$ | 11 | 2 | 0·2 |
| 57 | $kee'$ | F$-l+l'$ | 11 | 4 | 0·2 |
| 58 | $ke'^2$ | F$+2l'$ | 10 | 0·8 | 0·03 |
| 59 | $ke'^2$ | F$-2l'$ | 10 | 0·08 | 0·3 |
| 60 | $ke'^2$ | F | 10 | 0·4 | 0·03 |
| 61 | $kea$ | D+F$+l$ | 10 | 0·1 | 0·2 |
| 62 | $kea$ | D+F$-l$ | 10 | 0·2 | 0·2 |
| 63 | $ke'a$ | D+F$+l'$ | 10 | 0·2 | 0·003 |
| 64 | $ke'a$ | D+F$-l'$ | 10 | 0·5 | 0·003 |
| 65 | $ka^2$ | F | 8 | 0·004 | 0·06 |

to the fact that this portion of the work is peculiarly liable to numerical error. He may therefore be congratulated on having obtained an algebraical solution, reducing the operation of finding fresh terms to mere multiplication of series. The mathematical investigation is referred to as destined for publication elsewhere, and does not appear in the memoir. The underlying principle is that when in a differential equation of the $n$th order there are $n-1$ integrals known, when the right-hand member of the equation is zero, then a particular integral in the general case can be obtained. In the lunar theory the differential equation is, in effect, of the fourth order, and three integrals are known, two representing the elliptic inequality and the third a variation of the epoch.

For forming the right-hand sides of later stages, the quotient of each set of terms by the variation terms is required. As divisions are troublesome, these quotients are the quantities sought in the first instance: the new set of terms can then be obtained by a multiplication. The quotients referred to are given algebraically as the sum of four products, each product being that of two series. It is inconvenient, in the numerical application of the above method, that small coefficients often appear as differences of comparatively large numbers. Dr. Brown gives as an example a case where a coefficient 2 arises as the sum of separate coefficients

$$-6418+6496+316-392$$

from the above-mentioned four products.

Terms of long period require a special treatment, but the general methods apply to the other terms of the group. The loss of accuracy is reduced to that due to the first, instead of the second, order of the small divisor.

When the period is that of the elliptic inequality, a new part of the motion of the perigee has to be determined. Calling this new part $c_{\lambda/e}$ a new unknown term $\zeta^{-1}(\mathrm{D}+m).u_e c_{\lambda/e}$ appears, and is transposed to the right-hand side of the equation, so that the quantities A, which in other cases are completely known, now appear in the form $\mathrm{B}+c_{\lambda/e}b$, where B, $b$ are known. Dr. Brown has already shown in the first part how $c_{\lambda/e}$ may be obtained before the coefficients of the inequalities are calculated. When this has been done, one of the equations becomes redundant. Another is already redundant, until the meaning of the arbitrary constant denoting the ellipticity is defined with further precision. Dr. Brown defines the arbitrary constant so that $\epsilon_0-\epsilon_0'=1$ to all orders; hence $\lambda_0=\lambda_0'$. The other coefficients $\lambda_\iota$, $\lambda_\iota'$ consist of three parts, one proportional to $c_{\lambda/e}$, and arising from the quantities $b$, a second arising from the quantities B, and a third proportional to $\lambda_0$. The two equations for which $\iota=0$ then give a double determination of $\lambda_0$, and furnish a check upon the numerical accuracy. Many of the quantities that occur in this arrangement of the computations are of service at subsequent stages.

The treatment of the third coordinate follows the same lines, and only differs in being more simple.

The foregoing table exhibits the extent of the calculations already performed, and the results of the first part are for convenience included in it.

The decrease of accuracy of the terms in the twenty-second and twenty-third groups is due to the period of one term approximating to the synodic period. Even in these cases, the coefficients are given to less than one-thousandth part of the least quantity that could be detected by observation.

P. H. C.

## *INVESTIGATIONS OF DOUBLE CURRENTS IN THE BOSPHORUS AND ELSEWHERE.*[1]

AS my books and papers are published chiefly in the Russian language, they are not very well known in this country. A short account of some of my results may therefore not be without interest. I cannot, in the course of my address, make you familiar with all my works, and wish at the present moment only to draw your attention to the interesting phenomena of double currents in the Straits of Bosphorus, Gibraltar, Bab-el-Mandeb, Formosa, and La Pérouse.

The Strait of Bosphorus joins the Black Sea and the Marmora Sea. The Black Sea water has in it—roughly speaking—half the quantity of salt found in the water of the Mediterranean.

[1] Abridged from a paper by Vice-Admiral S. Makaroff in the *Proceedings* of the Royal Society of Edinburgh (vol. xxii. No. 4, 1899).

The water of the lower strata of the Marmora Sea has the same composition as the water of the Mediterranean. The upper strata, say from ten fathoms upwards, contain water of intermediate salinity between the water of the Mediterranean and the water of the Black Sea. This difference in the salinity of the water is the chief reason of the enormous double current of the Bosphorus. Let us imagine that at a certain given moment the level of both seas is at the same height. The pressure of the column of water in the Marmora Sea will be greater than that in the Black Sea; the difference would increase with the depth, and it would disappear at the surface. For this reason, the water in the lower strata of the Marmora Sea rushes into the Black Sea, keeping close to the bottom. That rush of water after a certain time will raise the level of the Black Sea, producing a difference in the level of the two seas, which causes a superficial current to flow out of the Black Sea in the opposite direction to the under current. Here we see distinctly that the principal reason for the double current is the difference in the salinity of the water, and should that difference in salinity cease the double current would be discontinued. The fact is that in the Black Sea evaporation does not exceed the quantity of water supplied by rains and streams, and this excess of fresh water maintains the difference of salinity in the waters of the Black Sea and Mediterranean.

The existence of double currents in the Bosphorus was known long ago, and Marsilli in 1681, in his letter to Queen Christina of Sweden, has described them. Later they were somehow forgotten, and some interesting papers have been published, in which the authors try to prove that the double current was legendary. Rear-Admiral Sir W. J. L. Wharton (who is now at the head of the Hydrographic Office) was the first to show by direct observations that a double current existed in the Bosphorus. I was there a few years after him, commanding the stationary steamer *Taman*. I began to take observations of the specific gravity of the water at different depths, and I found out that the water forming the lower strata contained twice as much salt as the water of the upper strata; after this, a double current was quite evident to me.

I do not wish to detain you with an account of the different results referring to the velocity of both currents, and will only point out to you that the lower current is similar in many details to an ordinary river, while, on the contrary, the upper current differs much from an ordinary river, probably for the reason that, while the surface of it is falling gradually down, the bottom rises constantly.

The difference of level of the Black Sea and Marmora Sea, calculated from the difference in the specific gravity of the water, I found for the month of July 1882 to be 1·396 feet.

In the Strait of Gibraltar I had only five stations, and made my observations one day only. I had no opportunity of measuring the velocity of the current, but the phenomenon is very similar to what I found in the Bosphorus. The water of the Atlantic rushes into the Mediterranean, the difference between the surface levels being, according to my calculations, 0·54 foot.

The evaporation of water from the Mediterranean is greater than the quantity supplied by rivers and rains. For this reason, the water becomes more dense, settles down, and goes back to the Atlantic by the under current.

I wish to point out here that the temperature of the lower strata of the Mediterranean coincides with the mean winter temperature of the air in the eastern part of the sea. This is quite evident, because in winter the temperature of the water to a great depth corresponds to the temperature of the air. In summer, the surface water is much warmer, but this high temperature cannot penetrate to a great depth. I am sorry that I have not time to discuss more fully this question, but in the Straits of Bab-el-Mandeb we have the same phenomena as in the Gibraltar Strait and Mediterranean. Here again—by my observations—the temperature of the lower water strata coincides with the winter temperature of the air at the place where the water settles down.

In the three straits already mentioned we have a double current: superficial and bottom current. In the Straits of Formosa and La Pérouse there are also two currents, but both are superficial.

I ought to mention that the influence of the rotation of the earth on the direction and velocity of the currents cannot be over-estimated. I shall not discuss this question fully, but the fact that in every salt inland sea there is a circular rotation of the water in a direction opposite to the apparent movement of the sun, shows that the rotation of the earth has very much to do with the direction of the currents. In the vicinity of islands, for the same reason, the water follows a direction coinciding with the apparent movement of the sun. It is for this reason also that the water alongside the Chinese coast flows to the south during the north-easterly monsoon as well as during the south-westerly monsoon. The Kuro-Siwo current going to the north and north-east cannot touch the Chinese coast because there is brackish water flowing to the south-west.

In the Strait of Formosa the specific gravity and temperature of the water at the Chinese coast are quite different from what is observed off the coast of Formosa. This difference in the temperature and specific gravity may give to a sailor a good guide for a fair passage through the Strait. The temperature of the water, say, in the month of February at the Chinese coast is 11° C., while at the coast of Formosa it is 20°. If the captain will try during the month of February to follow the line of the temperature of 15° he will pass at a good distance from the dangers of both coasts. Moreover, at the Chinese coast in winter it is possible to find water at less than 1·0240 $\left(S\frac{17·5}{17·5}\right)$, while at the coast of Formosa it is seldom less than 1·0265.

Every sailor knows how difficult is the passage through the Strait of Formosa. During the north-easterly monsoon the weather is very thick, and the depth of the sea cannot in these places be regarded as giving a good means for determining the position of the ship. It may happen that after a ship leaves, say, Nagasaki the captain never knows his position until he runs on the Chinese coast and wrecks his ship. My opinion is that a regular temperature service should be arranged from Turnabout Lighthouse; everyday a pilot boat should put to sea, taking temperatures both going out and returning, and the temperature of the water should be wired to all Chinese and Japanese ports for the information of the captains. By these means many ships would be saved from danger.

The currents in the Strait of La Pérouse are very complicated. There is a very narrow and long strip of cold water, which lies in the direction from N.W. to S.E.; a vessel crossing that strip in July may have temperatures of 18° C., then 5°, and again 16° or 18°. It would take me too long to explain the source from whence the cold water comes, and why it is constantly there; it is the cause of fogs which render navigation in that place very difficult. I may briefly say that the Kuro-Siwo current partly enters the Sea of Japan, and the excess of water escapes partly through the Strait of La Pérouse into the Okotsk Sea. Due to the rotation of the earth, the current turns to the south-east and flows alongside the Island of Yezo. This water is warm and dense, having much salt in it. The water of the Okotsk Sea—particularly in the vicinity of the Island of Saghalien—is in summer also pretty warm, but it is much lighter than the water of the Kuro-Siwo, and thus while the denser water sinks down, the lighter water tries to rise on the top of it. The difference of level which is produced hereby brings to the surface the cold water of the lower strata.

I studied this Strait in 1887 and 1888, and published the results of my study, but when I came to the Pacific again in 1895, as the Admiral commanding the squadron, I was very anxious to go to the Strait of La Pérouse to re-investigate the currents, and now I am in possession of very valuable material on this subject, which is almost ready for publication.

I do not propose to take up more of your time at present with particulars of these five straits. I only wish to remind you what important information the thermometer and hydrometer can give in the study of the different parts of our so little-known planet. You know better than I that studies in that direction ought to be continued, and no nation in the world has been so liberal as England, which found means to send out for four years the *Challenger* with a scientific staff to explore the deep sea. But it is not always possible to find such means, and it is advantageous to associate ordinary seamen with that kind of work.

I should be very glad if oceanographers would come to certain definite opinions with regard to the mode of collecting the information about the temperature of the surface water. It would be a great advantage to knowledge to divide the study of the sea with regard to the temperature. Suppose Russia should take Okotsk Sea, Bering Sea, or Sea of Japan, Black Sea, White Sea, Kara Sea, and the Finnish Gulf, England takes the Atlantic, United States takes Northern Pacific, Germany

takes Indian Ocean, France takes South Pacific, Sweden and Norway take North Sea, Baltic Sea and the Arctic Sea. Every nation should extract the information in regard to the temperature from ships' log books, put it in tables of approved description, and send it to the corresponding nation; this will give means to collect enormous information. The observations of every ship in a certain square ought to be placed on a separate card. Boxes containing these cards, say for the North Pacific, would not occupy more space than can be found in a good-sized book-case.

When a new journal of a ship is received, temperatures of sea water observed on board that ship should be placed on the cards, and the cards put in their corresponding place. In this way we should, each year, become richer in the knowledge of the temperature of the surface water, and no observation would be lost. Every observation would increase our knowledge of the temperature of sea water. It would be a real pleasure to see that progress of knowledge, and if ever this system or any other system be accepted, it will help us to study many details which, up to the present time, are unknown.

## *UNIVERSITY AND EDUCATIONAL INTELLIGENCE.*

MR. R. L. JACK, Government Geologist, Queensland, now on a visit to this country, is to receive the honorary degree of LL.D. of Glasgow University on July 20.

MR. E. A. MINCHIN, Fellow of Merton College, Oxford, has been elected to the Jodrell Professorship of Zoology in University College, London, in succession to Prof. W. F. R. Weldon.

THE Bill for establishing a Department of Agriculture and Technical Instruction in Ireland was read for a second time in the House of Commons on Thursday last, and referred to the Standing Committee on Trade.

FOR the purpose of encouraging the study of botany, the London Technical Education Board have had the botanical gardens in Battersea, Ravenscourt and Victoria Parks laid out upon an organised plan. Good collections of plants, representing various natural orders, have been obtained, and suitable arrangements have been made for the convenience of teachers and students. The more important trees and shrubs in the parks have been labelled, and lists have been supplied for insertion in the botanical guide which the Board proposes to issue shortly for the convenience of students. Teachers of botany can obtain tickets for themselves and pupils for admission to the botanical gardens at the Battersea, Ravenscourt and Victoria Parks by application to the Secretary of the Board.

BY the recent gifts of Mrs. Stanford (*Science* states), Leland Stanford Jr. University becomes the richest university in the world, far surpassing in its resources Harvard, Columbia, or any other university. The resources of the University consist of three great farms, aggregating 95,000 acres of land, deeded by Act of Legislature. On one of these farms, which constitutes the University Campus, buildings to the value of one million dollars were erected before Senator Stanford's death. By his will the University received 2,500,000 dollars in cash, invested in interest-bearing bonds. During the litigation following his death, Mrs. Stanford gave to the University (by deed) her own private fortune, amounting to about a million dollars. By her recent gift she transferred the residue of the estate to the University, it being necessary to do this by deed of gift under the laws of the State. The property just transferred has a commercial value—judging from the revenue stamps put upon the deeds—of 35,000,000 dollars. What its actual value may be only the future] can determine. The income arising from this final gift is at present relatively small, as by agreement among the railroads, in bonds and stock of which it largely consists, the earnings are for a time to be used in freeing the property from debt and in making improvements.

AT the annual dinner of the Old Students' Association of the Central Technical College, held on Thursday last, Prof. W. E. Ayrton, in proposing the toast of the Association, referred to the progress of the College and the insufficiency of accommodation due to the continued increase in the number of students. He announced that the electrical department would soon be greatly extended by the erection of a large new dynamo room nearly six times the size of that at present in use, and occupying a considerable part of the ground floor of the new building of the Royal School of Art Needlework adjoining the College. The accommodation for this department would be further increased by the completion of a new drawing office and a new lecture theatre. Sir Philip Magnus, in proposing the toast of the College and its professors, remarked that the College was that day entering on a new period in its career, for it was likely to become an integral part of the new University of London, which had decided the day before to move into new quarters at the Imperial Institute next door to the College. The needs of the College were recognised in the new University by the decision to appoint a faculty of engineering for the first time in the history of University education, and by the variation of the University matriculation examination to suit the requirements of different classes of students. Prof. Armstrong, in replying to the toast of the Chairman, alluded to the research work done at the College, especially in relation to its value as a means of mental training.

## *SCIENTIFIC SERIALS.*

*Bulletin of the Amerian Mathematical Society*, June.—Prof. F. N. Cole reports the April meeting of the Society held in New York City, and summarises the thirteen papers which were contributed. He also indicates where the papers themselves may be or will be found.—Surfaces of revolution in the theory of Lamé's products is a paper which was read by Dr. Safford at the February meeting. It is a review of an article by Haentzschel (reduction der Potentialgleichung), in which that writer criticises results obtained by Wangerin in the *Berliner Monatsberichte* (February 1878). Dr. Safford agrees with Wangerin in the results he gets, and so, in his opinion, invalidates Haentzschel's criticisms.—The next article is an enthusiastic review by Mr. Arthur Berry of Picard's "Théorie des Fonctions Algébriques de deux Variables indépendantes."—Another review is one of Jules Tannery's "Leçons d'Arithmétique théorique et pratique," by Prof. J. Pierpont. This latter is pronounced to be the first work on arithmetic which the reviewer has seen which, while intended entirely for secondary instruction, is written in accordance with the new ideas regarding the number concept and the need of rigour. Thus it is a pioneer of a revolution in secondary instruction.—Dr. L. E. Dickson contributes a note on Page's ordinary differential equations (*cf.* a review of this by Prof. Lovett in the *Bulletin*, April 1898).—The usual notes and new publications close the number.

IN the *Journal of the Royal Microscopical Society* for June, besides the usual summary of current researches in zoology, botany, and microscopy, is a further instalment of Mr. F. W. Millett's report of the recent Foraminifera of the Malay Archipelago; and an article by the president, Mr. E. M. Nelson, on the rackwork coarse adjustment, in which he traces the history of the application of rackwork to the focussing of the microscope from the time of Bonannus in 1691 down to the most recent improvements.

THE *Journal of Botany* for July contains an article, with illustrations, on a new British fresh-water alga, by Dr. A. B. Rendle and Mr. W. West, jun. The alga is a new species of the interesting genus *Pithophora*, first found by Wittrock in a tank in Kew Gardens. Like Wittrock's species, however, it has no claim to the title of "British" beyond the fact that it was found in a canal near Manchester, where it had unquestionably been introduced with cotton-bales. The remaining papers in both the June and the July numbers appeal to those interested in descriptive and geographical botany.

## *SOCIETIES AND ACADEMIES.*

### PARIS.

Academy of Sciences, July 3.—M. van Tieghem in the chair.—Considerations on the physical constitution of the moon, by MM. Lœwy and Puiseux. A summary of conclusions arrived at from recent photographic study of the moon. Certain

comparisons are drawn between the structure of the moon's surface and that of the earth, and evidence is adduced of the existence, at the present time, of a remnant of the original lunar atmosphere.—Examination of sea-water drawn from different depths: variation of iodine compounds therein, by M. Armand Gautier. Examination of water taken from the surface of the Mediterranean shows, as has been previously found to be the case with the Atlantic Ocean, the entire absence of iodides and iodates, the whole of the iodine present being contained partly in microscopic organisms and partly in combination with a complex organic substance which contains nitrogen and phosphorus, and is capable of dialysis. The total amount of iodine present is nearly the same for all depths, but the form in which it exists varies considerably. Thus, at the bottom of the sea iodine exists in the form of iodides and iodates to the extent of 0·305 milligramme per litre, and the quantity decreases with decreasing depth until it disappears altogether at the surface. On the other hand, the iodine contained in living organisms is greatest in amount at the surface, and gradually diminishes as the depth increases. The iodine present in the form of soluble organic compounds is much more constant in amount, the maximum quantity being found at a depth of 880 metres. The water of the Mediterranean appears to be somewhat poorer in iodine than that of the Atlantic, the total quantities found being 2·25 and 2·40 milligrammes per litre respectively.—Observations of Swift's comet (1899*a*) made with the Brunner equatorial at the Lyon Observatory, by M. J. Guillaume.—On the suppression of trial methods in the calculation of parabolic orbits, by M. L. Picart.—On the transformation of surfaces, by M. E. O. Lovett.—On the surfaces of Voss, by M. C. Guichard.—The groups of the order $16p$, $p$ being an odd prime, by M. Le Vavasseur.—On the development of a uniform branch of analytic functions in a series of polynomials, by M. Paul Painlevé.—On two integrable equations of the second order, by M. E. Goursat.—On a class of equations to partial derived functions, by M. Ivan Fredholm.—Considerations on the works of MM. S. Lie and A. Mayer, by M. N. Saltykow.—Wandering globular sparks, by M. Stéphane Leduc. When two fine metallic points are connected with the poles of an electrostatic machine, and placed in contact with the sensitive film of a photographic plate resting on a metal surface, an effluvium is produced around the positive point, and a luminous globule appears at the negative point. This globule increases in size, detaches itself from the negative, and slowly wanders towards the positive, point; on reaching the latter the luminosity ceases, and the machine is found to be discharged. The phenomenon suggests a comparison with globular lightning.—The frequency of nervous oscillations, by M. Auguste Charpentier.—On the nature and cause of the phenomenon of coherers, by M. Thomas Tommasina. An account of further experiments on the formation of conducting chains of metallic particles in coherers.—On the position of the points of magnetic transformation of nickel steels, by M. L. Dumas. The influence of chemical composition on the magnetic properties of steels is described and discussed.—On the volumetric estimation of zinc, by M. Pouget. In the new process here described the solution of zinc is treated with hydrogen sulphide and the precipitated zinc sulphide decomposed with a known amount of iodine solution, the excess of the latter being subsequently determined by titration with thiosulphate.—On the preparation and properties of the arsenides of strontium, barium, and lithium, by M. P. Lebeau. The arsenides of the metals in question were obtained by the reduction of the corresponding arsenates with carbon at the temperature of the electric furnace. They are reddish-brown substances presenting a crystalline fracture, and are rapidly decomposed by water with evolution of hydrogen arsenide and formation of the hydroxide of the metal.—A study of methylic oxymethylene-cyanacetate and some of its homologues, by M. E. Grégoire de Bollemont. Methylic, ethylic, and amylic oxymethylene-cyanacetates have been prepared from the corresponding ethereal salts, which have been previously described. These compounds exhibit the characteristics of strong monobasic acids, and may be looked upon as substitution derivatives of formic acid.—The use of tetrachlorohydroquinone for the characterisation and separation of fatty acids, by M. L. Bouveault. Tetrachlorohydroquinone reacts with one and two molecules of the chlorides of fatty acids to form stable, well-crystallised compounds which are easily purified, and thus eminently adapted for the identification, and in some cases for the separation, of the acids. The physical properties of some of these compounds are described.—On the presence in the animal organism of a soluble ferment which reduces nitrates, by MM. E. Abelous and E. Gérard. Experiments are described which show that the various organs of the body contain, in different proportions, a soluble substance of the nature of a ferment which reduces nitrates to nitrites. A temperature of 20–40° is most favourable to the reaction, which ceases altogether at 72°.—On the reducing power of urine, by M. Henri Hélier. The author determines the reducing power of urine by titration with potassium permanganate solution in the presence of sulphuric acid, the result being expressed with reference to urine of normal concentration, as measured by the amount of urea present. In many diseases, the reducing power is characteristically higher or lower than the normal.—Contribution to the study of the bark of *Rhamnus purshiana* (Cascara Sagrada), by M. Leprince. The presence is demonstrated of chrysarobin, chrysophanic acid, and emodine.—Direct transformation of acetamide into ethylamine by hydrogenation, by M Guerbet. The reduction is effected by means of metallic sodium in the presence of boiling amylic alcohol.—On the secretion of diastases, by M. Dienert.—Peculiarities of the eruption of Vesuvius, by M. Matteucci.

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THURSDAY, JULY 20, 1899.

## PRESTWICH AND PRACTICAL GEOLOGY.

*Life and Letters of Sir Joseph Prestwich.* Written and edited by his Wife. Pp. xiv+444. (Edinburgh and London: Wm. Blackwood and Sons, 1899.)

THIS is a pleasantly written personal history of a well-known man, and as such interesting to his friends who survive him and to the numerous friends of his friends who have passed away but are spoken of in connection with him. Scientific inquiry, however, filled so large a part of his life, and he did so much for the elucidation of certain branches of geological inquiry, that the story cannot fail to be more or less an account of the progress of research along those lines to which he devoted himself.

Born of a good north-country stock, Prestwich was sent to school while very young, and although people took a fancy to the spirited boy and were kind to him, he must have had to rough it somewhat in childhood. At sixteen he entered at University College, London, where he worked hard and successfully, but confined his attention, unwisely as he allowed in after life, too much to chemistry and natural philosophy to the neglect of mathematics and classics.

Yet it must not be supposed that he was a one-sided man, for he carefully apportioned his time when it was more at his own disposal, and went through a very full if not severe training. His extensive reading in English literature and his knowledge of the French language, acquired when a boy at school in France, and kept up in after life, proved of the greatest assistance to him. Joseph Prestwich, jun., was soon well known in the scientific world, and those social qualities and that genial temperament which made "Uncle Jovis' parties" so delightful to the happy children he loved to gather round him, enabled him also to do much to further the co-operation of scientific workers, and "Prestwich's Easter excursions" were not less highly appreciated by the geologists who had the privilege of joining them.

These excursions were certainly very pleasant and profitable. They were thoughtfully planned and well-managed. The party, generally consisting of one carriage load, met at some appointed spot. A few put their heads together when invited by the leader to do so, details were arranged, orders as to hours were given—these often involving a very early start—a call all round for say 10*l.*, which was carefully administered till spent, when a new call was made, then from each halting-place visits to points of interest, examination, discussion, demonstration, and home to dinner.

Among the illustrations in the book are excellent portraits of some of his more intimate friends, most of whom at one time or another accompanied him on his geological excursions.

He had for forty years to give most of his time and attention to business, but all his hours of leisure were spent and all his recreation taken in the pursuit of his favourite subject geology.

In his reply to the remarks which Sir Henry De la Beche made on presenting the Wollaston medal to him in 1849, he said:

"It is true that I entered upon this field as a student and for relaxation, but the interest and difficulties of the subject speedily induced me to take it up with more earnestness and determination, and eventually led me to extend the inquiry over an area which I, at first, never contemplated.

"The Tertiary geology of the neighbourhood of London may be wanting in beauty of stratigraphical exhibition and in perfect preservation of organic types, but in many of the higher questions of pure geology—in clear evidence of remarkable physical changes, in curious and diversified palæontological data, however defaced the inscriptions, which is after all but a secondary point—few departments of geology offer, I think, greater attractions.

"The pleasure I have derived from the study of the remarkable phenomena which have come before me in the course of the investigation has far outbalanced the few obstacles I have had to contend against. I, in fact, feel deeply indebted to geology, as a source of healthful recreation, as an inestimable relief and abstraction in due season from the cares frequently attendant upon the active duties of life, for its kindly and valued associations, and above all for the high communing into which it constantly brings us in the contemplation of some of the most beautiful and wonderful works of the creation" (p. 66).

Yet most of his work, undertaken and carried on in the true scientific spirit, bore directly, as it turned out, on questions of the greatest economic importance. This was, however, by accident, for he studied the Coal Measures in early life only because his holidays were spent at Broseley, where he got interested in the geology of Coalbrook Dale. And similarly the Tertiary and Cretaceous rocks of the London district offered in later life the most accessible sections, and so he plunged with his usual zeal into their discrimination and classification with no ulterior view to the practical application of the information he was then acquiring. But the knowledge which he gained of the characters and sequence of both these groups of formations was afterwards of immense value to the country, and we find him not only a member of the Coal Commission, but also one of the most trusted authorities on water-bearing strata.

His paper on Coalbrook Dale is a masterly sketch in which the fossils of different horizons are distinguished and the stratigraphical structure of the district is worked out with great accuracy and well illustrated by maps and sections.

To give an idea of his work on the Tertiary strata would be to give a sketch of Tertiary geology which is not wanted in a notice of this kind, for he established the classification which is now adopted with very slight modification.

He followed up the strata to the newest beds, and soon took part in the discussions which arose respecting the age and origin of the Glacial and post-Glacial deposits—controversies not yet settled, and inquiries out of which suggestions of new difficulties yet to be explained still continue to arise.

It is very interesting to follow the progress of opinion respecting the association of the remains of man with those of extinct animals in the river gravels, whose antiquity was further proved by their relation to the

physical geography of the country. There were doubts also as to the objects from the occurrence of which the presence of man was inferred, for, except in some very doubtful instances, it was not his bones that were found, but only flints roughly fashioned into serviceable instruments. A good sketch of the development of the inquiry appeared some years ago in *Blackwood's Magazine* (vol. clvii., June 1895, p. 939).

M. Boucher de Perthes had conceived the idea that so it must be, but it was long before he found sufficiently convincing evidence of the fact. At last, however, after Boucher de Perthes had been excavating, collecting, talking, and writing about it for years, Dr. Falconer visited him and acknowledged that a good *primâ facie* case had been made out, and wrote to Prestwich to say that he ought to look into it. Prestwich accordingly made a pilgrimage to Abbeville, and came to the conclusion that there were in Boucher de Perthes' collection flints which had undoubtedly been wrought by man, which had been found in undisturbed ground, and which were of the same age as the remains of the extinct mammalia found with them.

Boucher de Perthes supported a good theory with much bad evidence, and we must bear in mind from all that passed then that there is need for caution in disbelief as well as in belief, and it may be that Prestwich's conviction may prove well-founded, that in the plateau gravels of Kent and Wiltshire there are flints worked by man of much earlier date than the palæolithic implements the genuineness of which he had with so much skill and pertinacity established. At present, however, the evidence as to these Palæotaliths or Eoliths, as they have been called, is not quite satisfactory, for natural forms have been exhibited with too much confidence as the work of man.

The view that there has been a great submergence of our island since glacial times will probably turn out to be correct, though it may be that the lapse of time over which it extended has not been rightly estimated. But the opinion that the phenomena could be best explained by submergence of such a transitory and tumultuous nature as to be properly called a flood will not at present command general acceptance. Prestwich himself seems to have been willing to qualify very considerably the statements involving the idea of a flood.

In endeavouring to interpret the story of the later accumulations it was, of course, most desirable to search for any local conditions which tended to preserve the relics which were chiefly relied upon as evidence, and such conditions appear to be furnished by the caves in which are found sealed up the remains of man who lived or buried his dead there, of the wild beasts which crawled in to die, or dragged in the bones of other dead animals to feed upon at their leisure.

Prestwich therefore paid much attention to the hyæna dens and other caves discovered from time to time round the coast or in inland cliffs. His object was to establish some chronology from the associated objects, or make out certainly any relation between the contents of the caves and of the raised beaches or river terraces which were by degrees beginning to be understood.

Prestwich was so impressed by the vastness of the changes which had taken place even during the latest geological ages that he began to doubt whether the operations of nature which we see going on around us were sufficient to bring about such great results, and he further saw evidence of more violent action in many of the phenomena of recent date. While not reviving the old cataclysmic views, he questioned the wide application of the uniformitarian doctrines as taught by Lyell; but their views will be easily reconciled, first, by the doctrine that local catastrophic action is quite consistent with continuity of causation; and, secondly, by the admission of the inevitable effects of ever-recurring earth movements in hurrying up or retarding the operations of denudation and deposition.

The theory that there exists an underground plateau of Palæozoic rocks extending at an inconsiderable depth beneath the Secondary and Tertiary rocks of East Anglia, interfering as at Ware with the water supply, and raising hopes everywhere of a new source of coal supply, which was partly suggested by De la Beche and put into shape by Godwin Austen, and which was verified at Harwich, Ware, London and Dover, was, of course, a subject of the greatest interest to Prestwich, and the progress of the investigation was largely advanced by him.

He was a pleasant letter writer, but as time went on he seems to have confined himself more and more to the object for which he had taken up his pen, and that was generally some scientific point. His sense of humour was strong, but showed itself more in conversation than in his letters.

At his pleasant home on the chalk hills he spent many happy days in later life, and there he breathed his last soon after Royal favour had recognised his long services by designating him as one of the recipients of the honours granted on New Year's Day 1896.

His memoir is written in a loving spirit, and there will be few amongst its readers who do not entertain towards him that affectionate feeling of regard and respect that would be very ill content with any other treatment.

## *METEOROLOGY, OLD AND NEW.*

*Neudrucke von Schriften und Karten über Meteorologie und Erdmagnetismus.* Herausgegeben von Prof. Dr. G. Hellmann. Wetterprognosen und Wetterberichte des xv. und xvi. Jahrhunderts. (Berlin: Asher and Co., 1899.)

*Annals of the Astronomical Observatory of Harvard College.* Vol. xxxix. Pp. iv + 153. Part I. Peruvian Meteorology, 1888–1890. Compiled and prepared for publication by Solon I. Bailey, Assistant Professor of Astronomy, under the direction of Prof. E. C. Pickering. (Cambridge, U.S., 1899.)

*Annales de l'Observatoire national d'Athènes publiées.* Par Démétrius Éginitis, Directeur de l'Observatoire. Tome I. Pp. xxi + 395. (Athènes: Imprimerie Nationale, 1898.)

DR. HELLMANN has devoted himself with indefatigable application to the unearthing of those rare publications which illustrate the growth of an intelligent interest in the sciences of meteorology and magnetism, when these subjects first attracted attention

after the period of the Renaissance. Our columns have from time to time borne witness to his energy and to the merit of his selections. The present volume constitutes the twelfth of the series, and in matter of interest is not one whit behind any of its predecessors; while the beauty and fidelity of the facsimile reproductions will be acknowledged on all hands. In a short preface, Prof. Hellmann sketches the growth of the popularity of treatises on weather prediction, which circulated in great numbers before the close of the fifteenth century, whether in the form of almanacs or works of even greater pretension. The substitution of the language of the country for the learned Latin, which was in more general use prior to 1470, gave a great stimulus to the circulation, and on the continent of Europe these pamphlets and broadsheets won for themselves a warm welcome. Of the remains of this large harvest which have come down to us, Prof. Hellmann offers some typical selections, accurately reproduced as they circulated from hand to hand among various nationalities. Italy seems to have been earliest in the field to minister to the popular longing for this kind of literature, but later had to give way to German perseverance, which has won for itself the doubtful reputation of producing the greatest number of these almanacs. Prof. Hellmann has already given a catalogue of 600 distinct publications, but later study has made him acquainted with many more, and he now places the number at not less than 750. England and France, judged by the number of examples that have been preserved, do not seem to have exhibited anything like the same eagerness for the possession of this kind of writing which Germany, Italy, and the Netherlands exhibited. But specimens of all these various productions, graduated in point of time throughout the sixteenth century, are now made accessible to the student. England is represented by "An Almanacke and Prognostication" for 1555, by A. Aksham, priest and physician, which in the main outline differs but little from much earlier productions. An excellent example, dated 1506, due to the fancy of Leonardo de Richi, is presented in facsimile. As a rule it may be said that these various prophecies and indications begin with a dedication to some notability, then follow predictions relating to fruitfulness, conditions of health, wars and peace, in which is prefigured the fate of nobles and States, and towns and countries, and finally the times of moon changes are added, a knowledge of which is not only necessary for predicting the weather, but indicate the proper times for blood-letting and surgical operations. A modest section suffices for indicating the variations of the weather. We may quote an example from the Prognosticon of Julian de Blanchi which relates to October: "October ventosus et in eo aquae et tonitrua apparebunt, et dies dispositi ad aliquam aeris alterationem erunt iii., v., vii., xiii., xx., xxii., xxvi., xxxi."

The second volume quoted above refers mainly to an inquiry into the climate of Peru, but possesses a feature of distinct interest, to which we shall refer later. Peru has been roughly but conveniently divided into three regions, marked by the peculiarities of coast, mountain and forest climate. More particularly in two of these different localities, the enterprise of Prof. Pickering has established fully equipped meteorological observatories, and the present volume contains the discussion of the measures made at these stations between 1888–90. Mollendo, nearest the coast, is situated on the narrow strip of rock and sand which marks the abrupt rise of the continent from the waters of the Pacific. Chosica, further inland, is about twenty-five miles north-east of Lima. Here the climatic conditions fall midway between those of coast and mountain; for the land rises gradually from the ocean in successive ranges, each higher than that preceding it. The station itself stands on the summit of a conical mountain some 7000 feet high. Vincocaya and Puno, the two remaining stations in actual working order, are distinctly of the mountains. The former is near the crest of the Western Cordillera, on a desolate plateau nearly 15,000 feet in elevation. Puno is on the western shore of Lake Titicaca, and is typical of the great plateau which lies between the Western Cordillera and the Bolivian Andes. A few observations were also made at Pampa Central, near the central western part of the great desert of Atacama. Prof. Pickering describes this region as possibly the most barren on the earth. Not even a cactus breaks the monotony of the view near this town. The ground is rich in nitrates and other salts of immense commercial value; but the absence of rain on a soil of this character makes the region absolutely barren. In districts so uninviting and remote from the conveniences of civilisation, observers are found who, often without any hope of pecuniary reward, devote themselves to the maintenance of a continuous meteorological record. Self-registering apparatus is sometimes used, but the monotonous registration of the amount and character of cloud and similar data which go to decide the climate of a country, can only be secured by regular personal supervision; and though Prof. Pickering is obliged to reject some of the observations, owing to a suspicion of error, we think he is to be congratulated on securing an amount of co-operation which could hardly be anticipated in so inhospitable a country.

But the feature of special interest, and one that gives to the volume something of the charm that attaches to a work on travel, is the description of the establishment of two meteorological observatories near the summit of the lofty El Misti, a mountain which dominates the city of Arequipa, and from its symmetry, height and proximity constitutes the most imposing feature in the range of mountains that nearly encircles that town. It goes without saying that the approach to the summit is attended with great difficulties; but, rising as it does to a height of some 20,000 feet, or about 12,000 feet above the elevated plateau on which Arequipa stands, this truncated cone offers advantages to the meteorologist intent on studying the behaviour of the atmosphere at considerable elevations not less than the clear skies of Arequipa present to the practical astronomer. But only the most energetic would suggest to themselves the possibility of pursuing meteorological observations in a spot so inaccessible. Prof. Bailey gives us some account of earlier attempts, made at rare intervals, to reach the top of this venerated peak, some undertaken for the benefit of science, some from curiosity, but all, whether successful or not, accompanied with considerable danger and fatigue. Yet an observatory to be useful must be regularly and systematically visited. A tolerably

permanent mule track seemed to Prof. Bailey the best and only means of reducing the hardship of the ascent, and with true American ingenuity and enterprise he undertook the task of making a passable road up the sides of this barren mountain, over the remains of ancient lava streams and past huge slopes of volcanic sand, whose angle of ascent was oftentimes as much as 30°. Indians and Spaniards alike ridiculed the attempt, but Prof. Bailey persevered with his design, in spite of fatigue, mountain sickness, sulphurous vapours and the yielding character of the ground, into which the feet of the mules would sink six inches at each step. How he finally succeeded is modestly described in a chapter of great interest, to which we must refer for particulars. We can only record that at an altitude of 15,000 feet, approximately that of Mont Blanc, but in this latitude beneath the line of perpetual snow, the first observatory hut was set up, and, cheered by this success, it was resolved to attack the summit of the crater, and now eight feet above the highest point of the mountain a Robinson anemometer is successfully mounted, giving a continuous record of wind velocities in this elevated region. Other instruments from which records are obtained are a Richard self-registering hygrometer and thermograph, which register continually for ten days without interruption. Special thermometers and apparatus are mounted in a hut six feet square and seven feet high, on the very top of the mountain, a monument of well-directed vigour and indomitable resolution on the part of the director. We can but offer our congratulation on the completion of a work of so much difficulty, and hope that the results will equal in interest the labour by which they have been secured. Whatever may be the final outcome of mountain meteorology, Prof. Pickering has definiteiy secured, through the untiring efforts of Prof. Bailey, a chain of meteorological stations from Mollendo on the Pacific to the headwaters of the Amazon.

We have, unfortunately, but little space to do justice to the work of M. Éginitis. A thick volume filled mainly with meteorological observations and their discussion is apt to prove somewhat wearisome reading, but the director has managed to introduce some features of interest. In fact, the publication of the volume itself, indicating as it does the renewed activity of an observatory which has been practically non-existent since the death of Dr. J. F. Julius Schmidt, cannot but be welcome, and we may venture to hope that the observatory from which so much valuable work has emanated in the past will again be found among the institutions that contribute to the progress of science. M. Éginitis gives in an interesting chapter the history of the observatory since its erection, a record which in spite of sundry interruptions should prove inspiriting, since it demonstrates that the energy and ability of successive directors have risen superior to the difficulties inseparable from small instruments and straitened means. The volume is divided into two parts; in the first the climate of Athens is discussed, the treatise being enlivened by the introduction of many extracts from the old classical authors. In the second part are given the readings of the various instruments, by the discussion of which the climate is determined.

W. E. P.

## *MACHINES FOR THE LIQUEFACTION OF GASES.*

*Liquid Air and the Liquefaction of Gases.* By T. O'Conor Sloane, Ph.D. Pp. 365. (London: Sampson Low, Marston, and Co., Ltd., 1899.)

THIS book may be regarded from three points of view: (1) as a popular account of recent work and experiments; (2) as a scientific examination of the same: and (3) as a historical summary and appreciation of invention in a special branch of science. As an instalment of popular science it has much interest. Readers who, guiltless of any exact science themselves, like to know what is going on in the modern scientific world, will find here a good deal that will help them to understand the significance of such steps in advance as are from time to time reported. As an exact critique of the progress of invention it is not a success. On p. 300, for instance, Dr. Sloane says: "The origin of the methods used by Tripler, Hampson and Linde can be studied in the records of the Patent Offices." Then referring to Mr. Tripler's patent of 1893, he says the apparatus therein described "is based on self-intensification for the production of cold. The Joule-Thomson effect is not appealed to in it." Shortly afterwards he says: "Linde and Hampson have both invoked" the Joule-Thomson effect "as the principle on which their machines operate." The teaching here, that, whereas the initial cooling in the Linde and Hampson machines is identical with the Joule-Thomson effect, it is in the Tripler machine produced in some other way, is entirely without justification and contrary both to good science and to common sense. The machines are all three based on the Joule-Thomson effect, and all three involve the use of self-intensification, while neither of these means is applied in Mr. Tripler's 1893 patent. More astonishing still, if Dr. Sloane is to be regarded as a scientific writer, are his approving references to this patent (its number, which he does not give, is 4210). This patent Dr. Sloane accepts as giving "a clear description with drawings" of a self-intensive refrigerator from which Mr. Tripler's present apparatus is derived. The apparatus is not a refrigerator at all, for it contains a fatal fallacy, the omission of cooling coils after the pump, to remove the heat of compression; while the circuit is so arranged that for liquefying air no such coils could be introduced. The apparatus therefore, designed to produce cold, is a generator of heat. Secondly, even if it produced initial cooling, as expected, such cooling could never be intensified, since there is no self-intensive interchanger. An interchanger, to make the cooling effectively self-intensive, must have one end at the higher temperature, where the compressed air enters, the other end, where this air expands, at the extremely low temperature, and a continuous gradation of temperatures between them. In Mr. Tripler's patent there is no interchanger in which such an arrangement is possible. Again, on p. 295, Dr. Sloane praises Mr. Tripler's apparatus for its extreme simplicity, as using no refrigerant; and after describing Dr. Linde's more complex laboratory system, with its preliminary refrigeration by ice and salt, he says, on p. 320, that the Hampson

and Linde systems are very similar, and work "precisely on the same lines." The truth is that the Linde apparatus works with air at three pressures, uses preliminary refrigeration by ice and salt, has widely coiled helices consisting of three pipes placed concentrically one within the bore of another, and takes from two to three hours to liquefy air; while the Hampson and Tripler plants, working from a compressor, both have air at two pressures only; both use no preliminary refrigeration, both have simple pipe closely coiled, and both liquefy air in less than fifteen minutes. It would therefore have been more correct, since the Hampson machine is the older of these two, to change the names used by Dr. Sloane, and say that the Tripler apparatus "is very simple, and resembles very much the" Hampson "apparatus, and it works precisely on the same lines."

The salient feature of the book, as a historical summary and appreciation, is the glorification of Mr. Tripler and American invention. The greatness of Mr. Tripler's achievements is compared to his advantage with the paltry efforts of European experimenters in many places, as on pp. 255, 289, 290, 355, and 356; and on p. 296 he is roundly called 'the originator of the self-intensive system." Dr. Sloane's repeated use of the phrase "back of" instead of "behind" suggests that he is probably an American; and if that is so, patriotism might be allowed to excuse the over-laudation of a fellow-countryman in cases of real merit. It cannot, however, justify the ascription of unreal achievements. Mr. Tripler did not show to the public his liquid air made by the self-intensive method till 1897, nearly two years after that method had been published and fully described in Europe; and as he has produced no evidence of having used it privately before, he cannot be accepted as its "originator." Dr. Sloane, it is true, in a summary of Mr. Tripler's work as the inventor of the self-intensive process, says on p. 288 that "about 1891 air was liquefied" by that gentleman. If this be true, both Dr. Hampson and Dr. Linde must give up their claims to priority; but something more than this vague and unsupported statement is necessary to prove that Mr. Tripler had invented the process before November 1894 and May 1895, the earliest authenticated European dates for the invention. It is indeed inconceivable that, if Mr. Tripler had understood the subject well enough to invent and successfully work the process in 1891, he could in 1893 have devised the futile and absurd scheme described in his patent of that year referred to above. Mr. Tripler's later apparatus, too, is insufficiently explained and authenticated if his claims to the invention of it are to be seriously considered. Dr. Sloane must know that the chief interest of this process centres in the arrangements for expansion and interchange of temperatures, and in illustrating the European systems he very properly gives sectional views which clearly explain the nature of these arrangements. But in illustrating Mr. Tripler's machine, while he gives needless views and descriptions of the rooms, the people, and such well-known appliances as three-stage compressors, coolers, and washers, he shows only the outside of the vitally important interchanger. Why did not Dr. Sloane ask for sectional views of this and of the mysterious "special valve, the invention of Mr. Tripler"? We could then have judged how far they really differ from those shown and used in Europe nearly two years before. He informs us in the preface that his requests for assistance in the compilation of his book met with quick response from Mr. Tripler among others. In connection with liquid-air processes there has been too much mystery made, the public being freely asked for their admiration and faith without being frankly made acquainted with the details of an inventor's process and the evidence of his originality. Strangely enough Dr. Sloane, who so complacently accepts Mr. Tripler's mysteries, is himself, on p. 238, an objector to their prevalence in similar work at the Royal Institution. So much attention has lately been excited by Mr. Tripler's scheme for using liquid air as a means of providing unlimited power without cost, that Dr. Sloane might fairly have been expected to give his unscientific readers some useful guidance by explaining how these schemes violate hitherto inviolable laws as to the latent heat of volatilisation of gases, and are, in fact, blunders due to a mistaken interpretation by Mr. Tripler of one of his experiments. Instead of this, Dr. Sloane, on p. 289, gives Mr. Tripler's schemes a mild approval and support by saying that

"the utilisation of the low-grade heat energy of the universe presents nothing essentially impossible. This heat Tripler hopes to utilise. If it is utilised, &c. . . ."

Such toleration of Mr. Tripler's amazing proposals would disqualify any writer as a serious scientific critic.

## A MANUAL OF ANTHROPOLOGY.

*The History of Mankind.* By Prof. Friedrich Ratzel. Translated from the second German edition by A. J. Butler, M.A.; with Introduction by E. B. Tylor, D.C.L., F.R.S. With coloured plates, maps, and illustrations. Three volumes. Pp. xxiv + 486 + 562 + 599. (London: Macmillan and Co., Ltd., 1896.)

THE student of anthropology will welcome this handsome English edition of Prof. Ratzel's "Völkerkunde" as an invaluable work of reference for the numerous and scattered branches of his study. Perhaps no department of science embraces so large a field as the study of man and the history of civilisation, and in proportion to its complexity the greater is the necessity for some general guide to the subject. On the first publication of the work in the years 1885–88 it was at once recognised as the most comprehensive survey of the state of our knowledge of the lower races of mankind that had hitherto appeared, and since that time it has maintained its position in Germany as the standard popular work on the subject. The present English translation has been made from the second German edition and may therefore be regarded as in all essentials abreast of recent research. In his Introduction, Prof. Tylor has called attention to the large number and accuracy of the illustrations with which the book is furnished, and which he well remarks surpass in excellence any that have yet been issued in similar works intended for general circulation. The importance of good illustrations in contrasting the successive stages of the development of the human race cannot be over-estimated, for they convey far more to the general

reader than long descriptions and strings of technical terms.

In the main the book may be regarded as the best introduction yet available for the beginner who wishes to gain a general knowledge of anthropology and its results as applied to the study of the barbarous and more primitive races of the world. The book is not intended as a guide to the literature of the subject, nor as a work of reference for every specialist in his own department of the science, but is throughout addressed to the general reader. With this aim in view, Prof. Ratzel has disencumbered his pages of all foot notes and references to authorities, and has applied himself to giving, as far as possible, a sketch of results without overloading any portion of his work with the discussion of technical or unnecessary detail. In so doing, the author has been well advised, for not otherwise could his outline have approached completeness within the limits to which it was necessarily restricted.

Prof. Ratzel has treated his subject in five sections or books, the first of which is introductory, while the others roughly correspond to the principal ethnological divisions of the human race. In Book i. he has given a very clear sketch of the principles of ethnography, describing the distribution and general aspects of mankind, the rise of civilisation, and the development of language, religion, science and art, and family and social customs. The next three books describe the more important undeveloped races of the present day. Thus Book ii. deals with the American Pacific group of races, under which heading are included the races of Oceania, the Australians, the Malays and Malagasies, the American tribes, including the ancient civilised races of America, and the Arctic races of the Old World. Book iii. is devoted to the light stocks of South and Central Africa, such as the Bushmen, the Hottentots and dwarf races, while Book iv. deals with the Negro races found throughout Africa. Book v., the last section of the volume, gives a general sketch of the cultured races of the Old World. This brief summary of the contents of the volumes will serve to indicate the very comprehensive character of this history of mankind. The treatment of some of the sections of the book might perhaps have been a little fuller with advantage, but, even in sixteen hundred pages, considerable condensation was obviously necessary; and with so trustworthy a guide as Prof. Ratzel the reader need not fear that any essential facts have been inadvertently overlooked. A special word of praise should be given to Mr. Butler, not only for the excellence of his translation, but also for the care with which he has verified and corrected the descriptions of the numerous illustrations in the text.

## *OUR BOOK SHELF.*

*A Theory of Reality.* By Prof. George Trumbull Ladd. Pp. xv + 556. (London: Longmans, Green, and Co., 1899.)

PROF. TRUMBULL LADD'S "Theory of Reality," though intelligible in isolation, is a sequel to his "Philosophy of Knowledge" published in 1897, and a link in a chain of development beginning so far back as 1887. The Yale professor makes severe demands upon his public. His voluminous and discursive activity has now produced its fifth harvest, and we take it that there is at least a sixth to come. A certain condensation, therefore, and the taking of some things, *e.g.* the propriety of metaphysics, for granted, would not be out of place. Whatever be the case with the category of time, the reader's time is not unlimited. As compared, however, with its immediate forerunner, the irrelevance and repetition in the present work are only relative. And the review of his intellectual progress, with which the book closes, accounts in a not uninteresting way for his tiresome method of exposition.

Prof. Ladd's theory, which is avowedly speculative, may be described as a Realism of Spirit. It takes its starting-point from self-felt activity, finds "trans-subjective" elements involved in every cognition, and projects upon these by way of analogy the notion that they, too, are real centres of self-activity. "Things are known as imperfect and inferior selves." "The inner reality of all beings is spirit." "The transcendental reality of time is the all-comprehending life of an absolute self." "Viewed in its ontological aspect, all the growth of man's cognitive experience reveals the being of the world as a unity of force, that is constantly distributing itself amongst the different beings of the world so as to bestow on them a temporary *quasi*-independence, while always keeping them in dependent inter-relations, for the realisation of its own immanent ideas." This is not idealism, though in its affirmation of spiritual unity it steals the idealist's thunder. The nature of our knowledge of self and of the dynamical character of its agency necessitates realism; though, on the other hand, because connection according to some law must be predicable of reality, we are able, in the most satisfactory chapter of the book, to consider reality as an actual harmony of categories.

The interdependence, and neither independence nor dependence, of the categories is admirably treated, and Prof. Ladd discusses each in turn. He has in general (Pref., p. ix.) submitted the chapters which come into closest relations with the physical sciences to expert friends and colleagues. The treatment, however, of matter and ether as separate kinds of entity, though it may follow from his scientific definition of matter, presents difficulty to the metaphysical reader. Is ether then immaterial? The explanations of pp. 447–448 only partially solve the knot. Nor is it possible to agree with the symbolisation of time as a continuous flow of $n$ infinites, and of space as in each moment an infinite content which equals and is known to equal $n$ terms (p. 250). Prof. Ladd's point is, of course, to express the infinite simultaneous, but his symbols are misapplied.

H. W. B.

*Great and Small Game of Africa; an Account of the Distribution, Habits, and Natural History of the Sporting Mammals, with Personal Hunting Experiences.* Edited by H. A. Bryden. Pp. xx + 612; illustrated. (London: Rowland Ward, Ltd., 1899.)

THIS magnificent volume is a unique work on the subject of which it treats; the greater part of the text being written by well-known African sportsmen (among whom Mr. F. C. Selous occupies a prominent position), while a naturalist is responsible for the classification, nomenclature, and the leading distinctive features of the main groups. It is thus written throughout as the result of actual experience, and accordingly possesses a value far above the ordinary type of natural histories. Although mainly written for sportsmen, the professional zoologist cannot fail to find much matter bearing upon his own studies; and the African sportsman should no longer have any difficulty in identifying any of the species (unless they be new) which may fall to his rifle. The coloured illustrations, which for the most part are restricted to figures of the heads of the various species, are all that can be desired, both from an artistic and a zoo-

logical point of view. The book is invaluable to all interested in the natural history of Africa, and is especially important as indicating the number of game animals to be met with in British territories and dependencies.

R. L.

*An Introduction to the Carbon Compounds.* By R. H. Adie, M.A., B.Sc. Pp. viii + 90. (London: W. B. Clive.)

WITHIN the brief compass of this work the author aims at introducing the student to some of the chief groups of the carbon compounds, as represented by familiar substances, and at the same time at providing a series of experiments to illustrate the properties and reactions of these compounds. Thus the subject of the hydrocarbons is developed from an examination of the properties of coal gas, which leads to the study of marsh gas, ethane, olefine, acetylene and benzene. A feature of the book is that aromatic compounds are described along with fatty derivatives belonging to the same group, phenol along with alcohol, benzoic and salicylic acids along with acetic acid, aniline along with ethylamine, &c. This arrangement of the matter produces, no doubt owing to the severe compression, a somewhat disconnected effect, as it in many cases prevents a complete and logical discussion of the constitution of the compounds which are mentioned. This renders the book less suitable for absolute beginners than for students who have already a slight elementary acquaintance with the subject, and to these it cannot fail to afford valuable assistance. The experiments are on the whole well selected, but they are conducted on purely qualitative lines, no attention being paid to that important factor—the yield.

A. H.

## LETTER TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### On the Deduction of Increase-Rates from Physical and other Tables.

PROF. PERRY has called my attention to a want which sometimes arises in making practical deductions from tables. Take the following example.

| $\theta$ C. | $p$ | $\Delta p$ | $\Delta^2 p$ | $\Delta^3 p$ |
|---|---|---|---|---|
| 90 | 1463 | | | |
| | | 302 | | |
| 95 | 1765 | | 49 | |
| | | 351 | | **8** |
| 100 | 2116 | | **57** | |
| | | **408** | | 5 |
| 105 | 2524 | | 62 | |
| | | **470** | | 8 |
| 110 | 2994 | | **70** | |
| | | 540 | | **8** |
| 115 | 3534 | | 78 | |
| | | 618 | | |
| 120 | 4152 | | | |

The table gives in the second column the pressure of steam for the temperatures stated in the first column, which proceed by equal steps of 5°. The question is, how best to derive from these data the value of $\frac{dp}{d\theta}$ at one of the stated temperatures, say 105°.

The column $\Delta p$ gives the differences between consecutive values of $p$. The column $\Delta^2 p$ gives the differences between consecutive values of $\Delta p$, and so on. The third differences $\Delta^3 p$ exhibit so much irregularity that it is not worth while to proceed to fourth differences.

It is obvious that the required result is greater than $\frac{1}{5}$ of 408, and less than $\frac{1}{5}$ of 470. Half the sum of these two is a fair first approximation. Closer approximations can be obtained by means of the numbers printed in large type. Let the downward sloping series 470, 70, 8 be called $d_1$ $d_2$ $d_3$, and the upward sloping series 408, 57, 8 be called $u_1$ $u_2$ $u_3$. Also let the common difference 5° be denoted by $h$.

It is known to mathematicians that $h\frac{dp}{d\theta}$ is theoretically equal to $d_1 - \frac{1}{2}d_2 + \frac{1}{3}d_3 - \&c$, and also to $u_1 + \frac{1}{2}u_2 + \frac{1}{3}u_3 + \&c.$, both series being supposed to be continued till we reach an order of differences that vanishes.

In physical tables, usually no column of differences vanishes exactly, and the two series will not exactly agree. The question is, how to get the best practical approximation out of them. The most obvious plan is to add them, and write

$$2h\frac{dp}{d\theta} = (d_1 + u_1) - \tfrac{1}{2}(d_2 - u_2) + \tfrac{1}{3}(d_3 + u_3) - \&c.,$$

then to take the first bracketed expression, the first two, the first three, &c., as first, second, third, &c., approximations. But it will be found on trial, in the present instance and in most instances, that the second approximation so obtained is less exact than the first.

I find, on looking into the matter strictly, that the proper second approximation is

$$2h\frac{dp}{d\theta} = (d_1 + u_1) - \tfrac{1}{6}(d_2 - u_2).$$

This equation would be exact if $p$ were capable of being expressed in the form

$$p = A\theta + B\theta^2 + C\theta^3 + D\theta^4.$$

As applied to the example before us, it gives 87·7 as the value of $2h\frac{dp}{d\theta}$, and 8·77 as the value of $\frac{dp}{d\theta}$. This is as close an approximation as is warranted by the data. The first approximation $(d_1 + u_1)$ is 87·6.

The two series $d_1 - \frac{1}{2}d_2 + \&c$, and $u_1 + \frac{1}{2}u_2 + \&c.$, carried each to three terms, give respectively 87·53 and 87·83.

The proper third approximation, which would be exact for

$$p = A\theta + B\theta^2 + C\theta^3 + D\theta^4 + E\theta^5 + F\theta^6,$$

is

$$2h\frac{dp}{d\theta} = (d_1 + u_1) - \tfrac{1}{6}(d_2 - u_2) + \tfrac{1}{30}(d_3 + e_3).$$

Another requisite is to determine $\frac{d^2p}{d\theta^2}$. When the fourth order of differences vanishes, I find that $d_1 - u_1$ is the accurate value of $h^2\frac{d^2p}{d\theta^2}$. In the present instance this gives

$$\frac{d^2p}{d\theta^2} = \frac{62}{25} = 2{\cdot}48.$$

The formulæ most employed hitherto for this purpose are

$$h^2\frac{d^2p}{d\theta^2} = d_2 - d_3 + \frac{11}{12}d_4 - \&c.$$

$$= u_2 + u_3 + \frac{11}{12}u_4 + \&c.$$

which, if we include two terms of each, give respectively $\frac{62}{25}$ and $\frac{65}{25}$.

When fourth and fifth differences are worthy of attention, the correction to be made for them consists in adding

$$\tfrac{1}{6}(d_1 - u_1) - \tfrac{1}{12}(d_2 + u_2)$$

to the first approximation $d_1 - u_1$.

To take account of fifth and sixth differences, this correction must be supplemented by a further addition of

$$\tfrac{1}{15}(d_1 - u_1) - \tfrac{1}{30}(d_2 + u_2) + \tfrac{1}{90}(d_3 - u_3).$$

Without occupying space by a detailed investigation, I may say that my plan of procedure is first to write down (by Taylor's theorem) the expansions for the first differences in ascending powers of $h$; then so to combine them in pairs by subtraction as to eliminate all even powers; then to eliminate $h^3$ from two of the resulting equations. This gives.

$$2h\frac{dp}{d\theta} = (d_1 + u_1) - \tfrac{1}{6}(d_2 - u_2)$$

when $h^5$ is neglected.

The next approximation is obtained by eliminating both $h^3$ and $h^5$ from three of the equations.

In the first operation for deducing $\frac{d^2p}{d\theta^2}$ the pairs are combined by addition instead of subtraction, thus eliminating all odd powers of $h$.

This gives $d_1 - u_1 = h^2\frac{d^2p}{d\theta^2}$ when $h^4$ is negligible. The succeeding approximations are obtained by eliminating first $h^4$ and then both $h^4$ and $h^6$.

J. D. EVERETT.

## THE PENYCUIK EXPERIMENTS.[1]

THE well-devised breeding experiments now in progress at Penycuik under the direction of Prof. J. Cossar Ewart, are, it need scarcely be said, of the highest interest both theoretical and practical. To the general biologist the subject of hybridisation affords a wide field for the investigation of laws of heredity, and especially of such subsidiary factors, whether real or only imaginary, as reversion, prepotency, saturation and telegony; while the question of the sterility of hybrids has important bearings on the general theory of evolution. But besides the purely scientific aspects of the problems which are now being attacked by Prof. Ewart, there is also their practical application, which appeals with much force to the interests of the breeder of stock. It is of course true that the whole history of animals and plants under domestication may be said to provide a body of experiments in these and similar subjects on a very large scale; and it is undoubtedly the case that many of the questions referred to have been already answered, at least provisionally. The experience of many generations of breeders has led to the emergence of certain practical rules, which are seldom if ever disregarded by those whose interests are concerned in the rearing of animals with a definite object. But it still remains doubtful how far the widely-accepted doctrines of fanciers and other breeders rest upon any firm scientific basis; and it is certainly most desirable that precise experiments should be undertaken with the sole object of arriving at the truth in such matters as prepotency, telegony and the effects of inbreeding. It cannot but be to the advantage of breeders if empiric methods founded on vague conjecture and imperfect generalisation can be made to give place to a rational system derived from exact knowledge of facts. Prof. Ewart's design ought therefore to meet with a warm welcome in scientific and practical quarters alike.

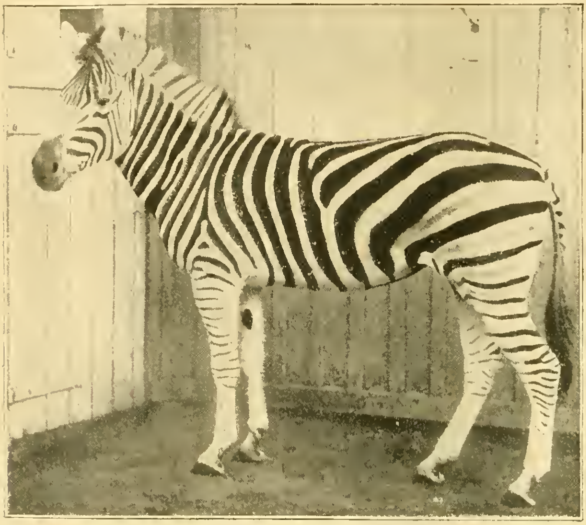

FIG. 1.—Matopo.

The volume before us contains an account of such results of the author's experiments as are now sufficiently mature for publication. It is not so much a book as a re-issue in book form of three papers that have already seen the light, together with a general introduction which, to some extent, summarises and supplements the information subsequently given. Prof. Ewart remarks that "as the problems under consideration are not of a kind that can be settled off-hand, and as one inquiry has begotten others, some years must elapse before a complete and systematic account is possible." Meantime, he thinks, the publication of his results in their present form "will indicate the lines along which the inquiries are proceeding, and also the kind of answers likely eventually to be made to some of the questions." Regarded in this way as an instalment, the volume well fulfils its purpose.

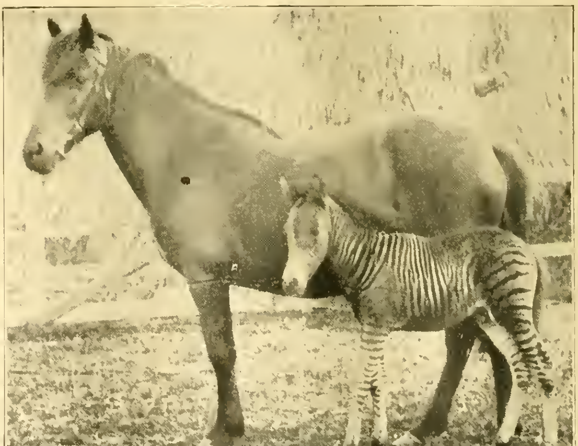

FIG. 2.—Romulus (seven days old) and his dam, Mulatto.

The first paper is chiefly devoted to a detailed descrip-

[1] "The Penycuik Experiments." By J. C. Ewart M.D., F.R.S., Regius Professor of Natural History, University of Edinburgh. Pp. xciii + 177. (London: Adam and Charles Black, 1899.)

tion of "Romulus," a hybrid colt whose sire "Matopo" is a Burchell's zebra of the *Chapmani* form, and whose dam "Mulatto" is an Island of Rum pony. "Mulatto" was afterwards crossed with a grey Arab stallion "Benazrek," and a description of her second foal, which unfortunately only lived for a little over five months, is given in the last paper under the head of "Telegony and Reversion." The foal in question was naturally a centre of great interest, inasmuch as from its parental history it afforded an opportunity for the operation of the alleged principle of telegony. The answer returned by nature to this particular interrogation was, as is so often the case, ambiguous. The colt was certainly striped, but the stripes were not like those of Mulatto's first mate; nor, on the other hand, did they entirely resemble those stripes often obscurely visible in ordinary foals. The evidence so far, though in no way conclusive, seemed to be capable of interpretation in accordance

FIG. 3.—Matopo.

with the theory of telegony. However, in the general introduction, after giving the results of a fresh comparison with pure-bred foals, and adding an account of three additional experiments of the same kind, the author concludes that in no one of these cases is it possible to maintain that infection, saturation, or telegony has taken place. The results of further trials with rabbits, dogs and pigeons have also at present been uniformly negative.

In the second paper, particulars are given of a further batch of hybrids sired by the same zebra stallion "Matopo"; the dams being respectively a Shetland and an Iceland pony, an Irish mare and a cross-bred Clydesdale mare. All presented points of interest, and the extent to which they resembled their sire or respective dams varied much, but it was found that even those which in several characters most distinctly suggested the zebra sire differed entirely from him in markings. According to Prof. Ewart, the markings of his hybrids accord fairly with those of the Somali zebra, which he regards as being the most ancestral in its colour-pattern of all recent Equidæ.

If this is really the case—and it is difficult to find any weak spot in the author's cautious yet cogent line of argument—the hybrids in question supply one more good illustration of Darwin's principle that the crossing of distinct species frequently leads to reversion. It may here be remarked that precisely the same conclusion seems to follow from the elaborate experiments in the hybridisation of insects recently conducted at Zürich by Dr. M. Standfuss. The latter investigator, it is true, speaks only of the "prepotency of the phylogenetically older" of the two parent species; but, while he refrains from actually using the term "reversion" with regard to his hybrids, he records the fact that some of them exhibit characters which must have belonged to an

FIG. 4.—Romulus.

ancestor of one of the parent species, though absent from the parents themselves.

With regard to the zebra hybrids now under discussion, the most striking point of difference in marking between "Romulus" and the other cross-bred foals on the one hand, and their common sire "Matopo" on the other, is the multiplication of stripes in the former, and the tendency to the production of a gridiron pattern over the rump. The last-named of these characters resembles the condition seen in the mountain zebra, an earlier form, according to Prof. Ewart, than the Burchell group, while the former point recalls the still more ancestral pattern of the Somali zebra. In the Shetland pony's hybrid, "Norette," the pattern over the hindquarters from the first resembled that of the Somali zebra; in the other hybrids, the markings of the same region, indeterminate at first, finally settled down into a form suggestive rather of the less remote stage marked

by the mountain zebra. The difference in the general system of striping between "Matopo" and his offspring is well brought out in the figures here reproduced, by the courtesy of the publishers, from Prof. Ewart's work. A more special point, but one of great interest, is that exemplified in the accompanying figures of the brow-stripes in "Matopo," in "Romulus," and in a Somali zebra. The numerous rounded arches shown on the forehead of "Romulus" are very different from the four or five acutely pointed arches of "Matopo," and clearly bear a much greater resemblance to the corresponding pattern of the Somali zebra. It should, however, be mentioned that a system of brow-striping not unlike that of "Romulus" occurs in Crawshay's zebra, a member of the Burchell group.

On one point of special importance the experiments have so far given results that, however interesting

FIG. 5.—Somali Zebra.

scientifically, are from the practical side disappointing. Following a suggestion of Captain Lugard, that zebra mules might possibly turn out to be immune to the disease communicated by the tsetse fly, and might thus help in solving some of the difficulties of African transport, Prof. Ewart, with great liberality, inoculated three of his hybrids with some of the tsetse organism at that time under investigation by Messrs. Blandford and Durham. The result of this experiment is not given in the present volume, but in the recently published *Proceedings* of the International Congress of Zoology at Cambridge it is stated that the inoculated animals, though apparently somewhat more resistant than horses, all died in about eight weeks.

The above-mentioned are a few only of the points of interest brought out by the remarkable series of experiments dealt with in the present volume, but enough has probably been said to show the importance of the problems which Prof. Ewart has set himself to solve, and the prospects of advance in knowledge which these researches hold out. It only remains to say a word in commendation of the general get-up of the book, and of the character and accuracy of the illustrations, which in many cases are reproduced from actual photographs. The absence of an index or detailed table of contents is a drawback, but this, like the frequent repetition of the same facts, is perhaps inseparable from the method of publication adopted. A tabular list of the hybrids, giving their parentage and the more important features of their aspect, might be a useful addition, as the reader finds it a little difficult at present to piece together the various details, scattered through many parts of the work, under their proper headings. But any small defects of this kind will, no doubt, be completely remedied in the connected and systematic account of the fruit of his researches which Prof. Ewart leads us to hope for at some future time. Meanwhile, the course of his experiments will be watched with keen interest by all those who realise the importance, both scientific and practical, of a right conception of the laws of heredity. F. A. D.

## PIONEER CLIMBERS.[1]

NOTWITHSTANDING what has been done by Coolidge and Freshfield, by C. E. Mathews and F. Pollock, for the pioneers in mountain climbing, there is still room for a book so comprehensive as that before us. Mr. Gribble has collected a quantity of interesting information, and prints at the end of his work several rare and curious documents. It is, moreover, not wholly restricted to the Alps, for it touches on early ascents in the Pyrenees and the Apennines. These, however, are distinctly subordinate; the interest, as is only natural, centres on the mountain backbone of Europe. This is many-sided, but on the present occasion we must restrict ourselves to aspects more or less scientific. A wide question is suggested at the outset: What caused that horror of mountains which was evidently so genuine among the chief nations of Europe till a period comparatively late in history? It was not felt by the Hebrew, as Mr. Gribble shows, but the Greek seems to have cared little for them, and the Roman detested them. Perhaps the practical nature of this people viewed them as an impediment to "imperial expansion," a sentiment hinted at in Napoleon's question, "When will the Simplon be practicable for cannon?" Moreover, in Rome's more luxurious days the rough roads, hard fare, and bad lodging of a journey across the Alps would naturally be objectionable. Classical influences, with a certain sympathetic similarity, may have caused the dislike once so general among our own countrymen, which has only been changed during the last thirty or forty years. These have witnessed a revulsion of sentiment which, whatever be its cause, is certainly one of the remarkable features in the later part of the nineteenth century.

But to pass from a general question to more particular topics, we can incidentally gather from this volume no bad idea of how some parts of scientific knowledge have advanced during the last four centuries. Prior to this epoch men knew little of science, and less of the mountains; pioneers were few, and the history of climbing—except when there was no help for it—was almost

[1] "The Early Mountaineers." By Francis Gribble. Illustrated. (London: T. Fisher Unwin, 1899.)

a blank. A monk of Canterbury, who crossed the Great St. Bernard late in the twelfth century, piously prayed that none of his brethren might come into that place of torment, and till long after that, though Leonardo da Vinci set a better example, and pilgrimages even began


FIG. 1.—John Tinner's Dragon.

to be made to the top of the Roche Melon, the Alps found few to praise them. Fancy invested them with superstitious terrors, of which the legend of Pilatus is an apt example, but here and there we come on the track of a sceptical traveller. In the first rank of these forerunners of the modern man of science is Conrad Gesner, who laughed at those stories, and was a true lover of the mountains. His successor, Josias Simler, even describes, about the year 1574, the precautions to be taken in crossing snowfields and glaciers, but the seventeenth century had begun before any careful note was taken of the latter. Then the fact of their motion was observed, and was communicated some years later, in 1669, to our own Royal Society; but the first speculations as to its cause appear to have been published by J. J. Scheuchzer, a professor, like the two first-named, at Zürich. Though evidently ill-adapted for mountain walking, he stuck bravely to it for some years at the beginning of the eighteenth century, and at last published two bulky volumes with numerous illustrations. These, in many respects, are interesting as a picture of Switzerland long before the coming of the tourist. But his book testifies to other changes, for it is full of dragon stories, and gives us portraits (such as that now printed) of many a loathly worm which now finds no representative on land, whatever it may do in the sea. Scheuchzer, in fact, though a good mathematician and a keen observer of minerals, plants, and even glaciers, had no critical faculty. He represents a type of student not yet extinct—the man whose first care is for "the literature of the subject," and who attaches an equal value to everything which appears in print. But before long in De Luc and Bourrit, and lastly in the really great De Saussure, scientific mountain travel begins, and the new era may be said to dawn. Now science finds in the Alps a workshop as well as a playground, and special memoirs such as that on Mont Blanc, noticed in these columns on June 15 (p. 152), are becoming common. Yet it is only just over a century since the last volume of "Voyages dans les Alpes" appeared.

Many curious illustrations, as we have intimated, are reproduced by Mr. Gribble, some indicating the strides which have been made in the representation of scenery, especially Alpine, during the last two centuries. The one given below was published about the year 1760, yet it bears little resemblance to nature, while some earlier than it are still more completely conventional. Incidentally the quotations in this volume throw light on the fauna of the Alps, showing, for instance, that bouquetin were common in districts from which they have long vanished. Indeed, odds and ends of curious lore abound in these pages; so that we have to thank Mr. Gribble, not only for an amusing book, but also for a valuable addition to Alpine literature. T. G. BONNEY.

## *BOWER-BIRDS.*

SINCE the year 1840, when Gould communicated to the Zoological Society an account of their extraordinary "runs," as they are locally called, the Bower-Birds of Australia and Papua have always attracted a large share of interest on the part not only of ornithologists but of students of the habits of animals. For in the construction of the "bowers" or "runs," from which they take their name, these birds stand absolutely alone, although the "playgrounds" of the Argus pheasant are comparable to the smooth patches cleared in the jungle by one species of Bower-Bird. On such an interesting subject it is of the utmost importance to have as much definite information as possible at first hand, and we are therefore glad to welcome the paper on the Australian representatives of the group, from the pen of an original

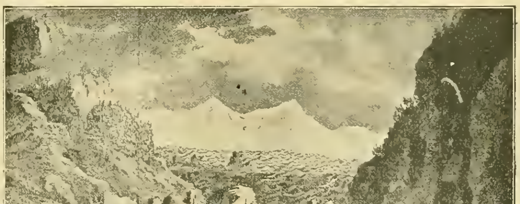

FIG. 2.—Grüner's view of the Lower Grundelwald Glacier.

observer—Mr. A. J. Campbell, of Melbourne—which appears in the last issue of the *Proceedings* of the Royal Physical Society of Edinburgh, special value attaching to this communication from the excellent photographs of "runs" and nests with which it is illustrated.

As there may be a lingering idea that the "runs" of these birds have some connection with nesting, it may be well to state that this is altogether a mistake. The nests, of which beautiful examples are figured by Mr. Campbell, present indeed no special features, being built at a height of from ten to fifteen feet above the ground, and usually containing at the proper season two, or sometimes three, eggs. These latter, however, cannot fail to attract the collector by their porcelain-like polish and beautifully pencilled markings. Thanks to the energy of Australian ornithologists, the nests and eggs of most of the species are now known, although some are rare and difficult to find.

"Run" of Great Bower-Bird. From a photograph taken in Western Australia by Mr. H. H. Johnston. (From the *Proceedings* of the Royal Physical Society of Edinburgh.)

Among the more elaborate types of "runs" or "bowers," the author figures those of the Satin Bower-Bird, the Spotted Bower-Bird, the Great Bower-Bird, the Queensland Bower-Bird, and the Regent Bird; the third of these being herewith reproduced. The photographs confirm previous statements as to the two types of decoration employed in these bowers, the taste of the Satin Bower-Bird displaying itself in the selection of bright-coloured parrot-feathers, while the other species named prefer bones and shells. The Spotted Bower-Bird may be described as a collector of sheep's bones (especially the vertebræ), whereas the Great Bower-Bird accumulates bleached shells. As is the case with the "Viscacherias" of the Argentine Pampas, in a Bower-Bird haunted country it is well to search the "runs" for any glittering objects, such as money or jewellery, which may have been lost in the neighbourhood. The amount of grass and sticks employed in some of these "bowers" is enormous, one structure being described as ranging from four to six feet in height.

In one respect Mr. Campbell does not agree with some writers, who have stated that the Cat-Birds (*Aeluroedus*) differ from other members of the group in that they build no bower, but content themselves with clearing a space of ground. No such spaces have, however, according to our author, yet been observed; and it is suggested that the birds may merely play on some fallen log. On the other hand, the Tooth-billed Cat-Bird (*Scoenopaeus*) of North Queensland does undoubtedly clear such spaces, upon which are laid at intervals a few leaves of one particular kind of tree. This represents the simplest type of "run," the most complex being that of the Gardener-Bird (*Amblyornis*) of New Guinea, which builds an orchid-covered hut, with a mossy lawn in front, ornamented with brilliant flowers and berries.

As to the object of these strange structures, Mr. Campbell has no new suggestion to offer, and we may therefore conclude that he accepts the old "playground theory." R. L.

## *THE COSMIC ORIGIN OF MOLDAVITE.*

MUCH attention has recently been devoted by Austrian and Bohemian geologists to the solution of an interesting question, that of the origin of those peculiar glassy bodies which are known collectively as moldavite or bouteillenstein. It has been considered by some authors that these fragments are to be looked upon as representing the relics of prehistoric glass-manufacture; but, as recently noted in the columns of NATURE, Herr J. Bareš has lately brought forward experimental proofs to refute the theory of the artificial origin of moldavite glass. Additional stimulus has been given to the study of this problem by the recent enunciation of a

new theory. Dr. F. E. Suess has expressed the opinion that these glassy fragments bear strong analogy to meteorites, and that they are in reality, like the latter, aerolites. In support of this view, in addition to other arguments, he lays special stress on the nature of the peculiar, though varying, surface sculpture of bouteillenstein, a sculpture not consistent with any theory of mechanical transport in water. Prof. Rzehak, however, has opposed this hypothesis of a cosmic origin, and brings forward arguments for its refutation. This author rather inclines towards the theory of an artificial origin; but Bareš, by experiments above referred to, applied a process of elimination to the various theories put forward for the terrestrial origin of the glass, and finally considered that of Dr. Suess to be most probably the correct one. A recent contribution to the literature of this subject is a short paper brought before the Böhmische Kaiser Franz-Josefs Akademie (Prague) by J. N. Woldrich last December. An abstract of this appears in the *Bulletin International* (dated 1898) issued by the Academy, and from the photographs illustrating that paper the accompanying figures have been selected for reproduction.

FIG. 4.

FIG. 8*a*.

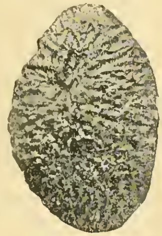

FIG. 6.

Herr Woldřich describes the surface markings of specimens in his own large collection, and points out the resemblance between certain of these Bohemian examples and the peculiar obsidian-bombs from Australia, described by Stelzner. Some of the Bohemian occurrences show, in fact, a hollow, bomb-like form. A fragment of such a specimen is represented in Fig. 8*a*. Figs. 4 and 6, photographed in natural size, show two characteristic types of sculpture, Fig. 4 exhibiting "finger impressions," and Fig. 6 a network of furrows, having in part a rough radial arrangement. The moldavite found both in northern and southern Bohemia occurs in sandy deposits which are regarded as belonging to either late Tertiary or early Diluvial time. Herr Woldřich considers that the known facts relating to moldavite and its distribution speak in favour of its extra-terrestrial origin, but that it is only known to occur in sandy deposits, whether in Europe or on other parts of the earth's surface, he regards as a striking circumstance.

## NOTES.

AT a meeting of the Glasgow University Court held on the 13th inst., Principal Story presiding, a petition for leave to retire from the chair of Natural Philosophy was presented from Lord Kelvin. The Court granted the leave asked, and accepted Lord Kelvin's resignation with deep regret. A remit was made to the Principal to prepare a minute to be signed by all the members of the Court, expressing their sense of the great loss that the University is now to sustain. Lord Kelvin has occupied the chair for fifty-three years.

DR. P. F. RAYMOND, the successor of Prof. Charcot in the chair of Nervous Diseases at the Saltpêtrière, has been elected a member of the Paris Academy of Medicine.

PROF. KLEIN proposes to spend two or three weeks in this country, so that, after the work of the Catalogue Conference is finished, he can have an opportunity of discussing, with our mathematicians and physicists, the plan and scope of the second part of the *Encyklopädie der Mathematischen Wissenschaften*, which deals with Applied Mathematics. The season for his visit is in some respects unfortunate, as being a holiday time; on the other hand, there is the advantage that those who are to be found at home will have plenty of leisure to devote to the discussion of the details of this great work.

THE death is announced, at the age of eighty-seven years, of the Right Rev. Charles Graves, Lord Bishop of Limerick, who in 1843 was appointed Erasmus Smith professor of pure mathematics at Trinity College, Dublin. His published work appeared for the most part in *Crelle's Mathematical Journal*, and many of his theorems are to be found in text-books on geometry. In 1841 he edited a translation, with considerable additions, of Chasles' "Memoirs on Cones and Spherical Conics." He was elected President of the Royal Irish Academy in 1861, and a Fellow of the Royal Society in 1880.

THE death is announced in the *Athenaeum* of Dr. Eugen Ritter von Lommel, Rector of the University and a member of the Academy of Sciences of Munich. He was the author of several works, including "Das Wesen des Lichts," "Wind und Wetter," and "Lexikon der Physik und Meteorologie."

THE negotiations which for some time past have been carried on between the Royal Geographical Society and the University of Oxford with a view to the establishment at Oxford of a fully-equipped school or institute of geography, for the use, not only of Oxford graduates and undergraduates, but of others who desire to avail themselves of such an opportunity, have come to a satisfactory conclusion, and the school will begin operations in October next, under the direction of Mr. H. J. Mackinder. The Royal Geographical Society is to contribute 400*l.* annually for five years out of the 800*l.* required, and the school will be under the supervision of a joint committee of representatives of the Society and the University. At a recent meeting of the committee, the staff was appointed, Mr. Mackinder being the head of the school, and dealing specially with historical geography; Mr. A. J. Herbertson has been appointed assistant to the Reader, and will deal with physical geography, cartography, and surveying; Mr. H. N. Dickson has been appointed Lecturer on Physical Geography; and Mr. G. B. Grundy will in 1899-1900 lecture on ancient geography. The work of the school will include a course of systematic instruction primarily intended for graduates and other advanced students, with classes, demonstrations, and practical work in physical geography, cartography, and surveying. Courses of lectures will also be given with special reference to the historical and scientific teaching of the University. The work will be carried on for five days each week during term. The lecture-room and laboratory will be in the Old Ashmolean

Museum, the upper floor of which is being fitted with the necessary appliances.

PARTICULARS have reached us of the autumn meeting of the Iron and Steel Institute, which, as has already been announced in NATURE, is to be held in Manchester from August 15 to 18 next. The following papers have been promised for reading :—On the constitution of steel, by Prof. E. D. Campbell ; on diffusion in steel, by F. W. Harbord and Thomas Twynam ; on the magnetic concentration of iron ore, by H. C. McNeill ; on India as a centre for steel manufacture, by Major R. H. Mahon, R.A. ; on pig iron fractures and their value in foundry practice, by J. W. Miller ; on practical microscopic analysis for use in the steel industries, by C. H. Ridsdale ; on the relation between the structure of steel and its thermal and mechanical treatment, by Albert Sauveur ; on the present position of the solution theory of carburised iron, by Dr. A. Stansfield ; on the iron industry in the territory of his Highness the Nizam, by Shamsul Ulama Syed Ali Bilgrami ; on a new casting machine for blast furnaces, by R. Hanbury Wainford ; on the utilisation of powdered iron ore, by Prof. J. Wiborgh. In the outline programme, just issued, full particulars are given of a number of excursions for which arrangements have been made.

THE summer meeting of the Institution of Naval Architects, which is taking place this week at Newcastle-upon-Tyne, was opened on Tuesday, when papers were read by Sir Andrew Noble (on "The Rise and Progress of Rifled Naval Artillery"), Dr. F. Elgar (on "The Distribution of Pressure over the Bottom of a Ship in Dock, and over the Dock Blocks"), and Mr. Nelson Foley (on "A New System of Forced Draught").

A CONFERENCE was held at the Home Office on Tuesday with some of the principal pottery manufacturers, in reference to the report by Prof. T. E. Thorpe and Dr. T. Oliver on the employment of compounds of lead in the manufacture of pottery.

*Science* states that a laboratory for the physical analysis of soils has been established by the Maryland Geological Survey. A full outfit of apparatus has been installed, and work will be engaged in during the coming year upon the soils of Maryland, in conjunction with the geological surveying of the same area. The Survey has also recently had constructed an elaborate calorimeter for the determination of the calorific power of coal, preparatory to the investigations of the coal formations of Maryland, an exhaustive report on which is promised for an early date.

THE Magnetic Observatory at Vienna having had to be discontinued in consequence of the electric tramways and electric light wires, Prof. Pernter has submitted to the Austrian Government a plan for a new observatory to be situated at some distance from Vienna, and to be provided with instruments of the latest construction.

ACCORDING to the *Pharmaceutical Journal*, a committee has been formed in France to organise a public subscription in aid of scientific research, with a view to the discovery of new methods of treatment for infectious and contagious diseases. That the need is pressing will be seen when it is stated that France loses every year by these diseases two hundred and forty thousand victims, nearly double the number of lives lost in the Franco-Prussian war of 1870. Out of this total, tuberculosis is responsible for 100,000 deaths ; typhoid fever and other contagious diseases, such as small-pox, measles, scarlatina, whooping-cough, diphtheria, and puerperal fever for 64,000, without speaking of the ravages caused at long intervals by cholera and plague.

THE committee appointed to inquire into the use of preservatives and colouring matters in food held their first meeting on Monday, when there were present Sir Herbert Maxwell, M.P. (in the chair), Dr. Timbrell Bulstrode, Dr. Tunnicliffe, and Mr. C. J. Huddart (secretary). The terms of reference to the committee were under discussion, and certain preliminary matters were disposed of, a second meeting being fixed for early in August to complete arrangements for the carrying out during the hot weather of necessary experiments in relation to the use of preservatives and colouring matters in one and another class of food, and to settle the scope of the evidence to be taken when the committee reassemble in October next.

THE Liverpool expedition for the study of malaria in Sierra Leone, to which attention has already been called in these columns, will sail on July 29. In addition to Major Ross and Dr. Annett, each of the Liverpool School of Tropical Diseases, the expedition will include Mr. E. E. Austen, of the British Museum (Natural History), and Dr. S. Van Neck, official delegate of the Belgian Government. The School of Tropical Diseases has recently been in communication with the various Government departments concerned with regard to the forthcoming research. On July 1 the Colonial Office wrote that Mr. Chamberlain had learned with great satisfaction that the expedition of the Liverpool School was being sent, and that he appreciated the energy and public spirit shown by the Committee of the School in the matter. Mr. Chamberlain also stated that the local authorities at Sierra Leone will be instructed to give every facility to the work of the expedition.

THE Vienna correspondent of the *Times*, telegraphing to that paper on July 14, says the renewed experiments by Prof. Tuma and a number of officers of the Vienna garrison to test the possibility of wireless telegraphy between two balloons were attended with a certain degree of success. A balloon held captive at a height of 150 metres served in place of the mast used in the Marconi experiments, being connected with the despatching instruments on the ground by a copper wire. The second free balloon carried a receiving instrument and a wire which hung loose 20 metres below the car. In these conditions it was found possible to communicate with the three officers in the free balloon, who signalled with flags that they had received and understood the telegraphic messages. These signals were observed at an estimated height of 1600 metres and a distance of about 10 kilometres from the despatching station. Owing to the size and weight of the accumulators and the great danger of bringing them into close proximity to a large volume of explosive gas, it is thus far impossible to telegraph from a balloon to the ground or from one balloon to another. On the return of the officers to Vienna a comparison will be made between the detailed particulars noted by them and the report of the actual messages despatched.

THE Liverpool Section of the Society of Chemical Industry proposes, with the approval of the Council, to perpetuate the memory of the late Dr. Ferdinand Hurter, especially his great services to applied chemistry, by instituting a memorial lecture to be given every second year on some subject connected with applied chemistry. The lecturer will be chosen by the Liverpool Section of the Society, and it is proposed to collect a sum of 300*l.*, which it is supposed will be sufficient for the endowment.

ON the afternoon of Saturday, July 8, a marble bust of the late Prof. William Rutherford, F.R.S., was unveiled in the Physiology Class-room of the University of Edinburgh by Principal Sir William Muir, in the presence of, among others, Sir William Turner, Prof. T. R. Fraser, Prof. Crum Brown, Prof. Hunter Stewart, Dr. Clouston, and Dr. E. W. W. Carlier. The Lord Provost of Edinburgh and Prof. Schäfer sent apologies for absence. The bust, which is by Mr. John Hutchinson, was

subscribed for by past and present members of the class of physiology. It bears the following inscription on the pedestal:—"In piam memoriam Gulielmi Rutherford, M.D., F.R.S., in Universitate Academica Edinburgensi, ab anno MDCCCLXXIV. ad annum MDCCCXCIX., Physiologiæ Professoris hanc effigiem posuerunt discipuli eius Universitatis huius cives. A.D. MDCCCXCIX."

Sir John Wolfe Barry, K.C.B., F.R.S., has been elected by the Council of the Society of Arts chairman for the ensuing year.

The fourth International Congress of Psychology will be held in Paris from August 20–25, 1900. The organisation is left to the French members, and the following are the officers: President, Th. Ribot, professor of experimental and comparative psychology in the Collège de France; Vice-President, Charles Richet, professor of physiology in the Paris Faculty of Medicine; General Secretary, Pierre Janet, Director of the Laboratory of Psychology in the Collège de France. The seven Sections and the Presidents are as follows: (1) Psychology in its relations to physiology and anatomy, Prof. Matthias Duval; (2) Introspective psychology and its relations to philosophy, Prof. G. Séailles; (3) Experimental psychology and psycho-physics, M. A. Binet; (4) Pathological psychology and psychiatrie, Dr. Magnan; (5) Psychology of hypnotism and related questions, Dr. Bernheim; (6) Social and criminal psychology, M. Tarde; (7) Comparative psychology and anthropology, Prof. Yves Delage. Those wishing to attend the congress should apply to the Secretary, and those wishing to present papers should forward abstracts not later than January 1 next.

A combined meeting of the German and Viennese Anthropological Societies is to be held at Lindau from September 4 to 7 of the present year.

An expedition to determine the geological and mineralogical features of the almost unknown region lying between Buffalo Hump, in Idaho County, Idaho, and the Nez Perce Pass, in the Bitter Root range, has been organised and equipped by Colonel W. S. Brackett, of Peoria, Ill. The party numbers twelve men, all of whom are stated to be experienced mountaineers.

Reports from Vancouver, British Columbia, announce the ascent for the first time of Mount Morrison, the highest mountain in Formosa, by Stoepel, the explorer of the Pic of Orizaba n Mexico.

Dr. D. J. Leech, professor of materia medica and therapeutics at the Owens College, Manchester, will deliver the address inaugurating the winter session of the Pharmaceutical Society on October 2, and on the occasion the Society's Hanbury medal will be presented to Prof. Albert Ladenburg, of Breslau, for his researches into the chemistry of the atropine alkaloids.

The "Board of Estimate and Appointment" for the City of New York has set aside 63,000 dollars for the zoological garden in Bronx Park. It is also proposed to raise the appropriation for the American Museum of Natural History from 90,000 to 130,000 dollars annually.

An appeal has recently been made in the Manchester press, by the President and Secretary of the Manchester Literary and Philosophical Society, for help in restoring the tomb of Dalton the chemist. The appeal is made "to those residents of Manchester, chemists and others, who are interested in the work and fame of John Dalton." It appears that the funds of the Society cannot be used for the purpose, but the Council "have felt that the continued neglect of the resting-place of one of Manchester's greatest worthies would be a scandal and a discredit." The sum of 75*l.* in all is the amount endeavoured to be raised, it being thought that the interest on the sum remaining after the payment of present repairs has been made will suffice for keeping the tomb in repair.

Mr. Griesbach states in the annual report of the Geological Department of India that last year a find of copper and gold was reported near the village of Rohera, a station on the Rajputana-Malwa Railway, in Sirohi territory. The place had evidently been worked for copper in ancient times, and to a considerable extent, as may be seen from the heaps of copper slag in the vicinity. The old mine had, however, not been sufficiently excavated at the time of the Director's visit to enable him to judge of the extent of the deposit.

A considerable amount of attention has, says the *Journal of the Society of Arts*, been given in France to what may be termed general agricultural education. Agricultural teaching, of a more or less rudimentary order, has been made obligatory at elementary schools, and a small garden for practical illustration has been attached to many of these institutions in rural districts, and the instruction thus given has, it is said, produced most beneficial results. The general instruction is given by departmental professors and special professors, whose duties may be divided into two distinct sections: (1) general instruction of adults—in the service of the Ministry of Agriculture; (2) teaching in the normal schools—in the service of the Ministry of Public Instruction. The tuition for adults takes the form of lectures, delivered in different parts of the department. The lectures are intended to enlighten landed proprietors, farmers, and others as to the best agricultural methods, the applications which can be made of scientific discoveries, &c.; in a word, to assist them in reaping the greatest possible profit from their land. The subjects treated naturally vary greatly according to the needs of the population of each department; the lectures, however, possess one characteristic in common, they are of an essentially "popular" type. The lecturer also, at the close of each lecture, places himself at the disposal of his audience, with the object of advising them individually regarding special questions, and of elucidating any points touched upon in his discourse which they may have failed to grasp. The most powerful aids to this class of teaching are found in the "experimental" and "demonstration" fields. Attention is also called to the agricultural stations and laboratories of the country, which, though not properly coming within the sphere of educational establishments, render considerable service to the agricultural population.

According to the *National Geographic Magazine*, forecasts for forty-eight hours in advance, for all States east of the Rocky Mountains, were, for the first time in the history of the Weather Bureau, regularly issued from Washington each night during April of the present year.

Orders issued by the Government of India to civil surgeons with entomological proclivities require them "to make collections of mosquitoes and other flies that bite men or animals, in accordance with the instructions contained in Prof. Ray Lankester's pamphlet," with a view of determining the possible connection of malaria with mosquitoes. For the general detructions of mosquitoes several methods have, says the Indian correspondent of the *Lancet*, been tried. In many places the engineer has been successful by draining the marshy areas. In others the use of kerosene by throwing it into the water where it forms a film on the surface has prevented the developing larvæ from reaching the air, and has thus brought about their destruction. A more recent experiment has been the employment of permanganate of potash, which is said to kill the insect in all stages of its development. As this chemical has also been

largely employed for purifying the water of doubtful wells, and especially with the view of protecting against the cholera bacillus, it would seem particularly applicable for use in India.

THE *Times* of Monday published a very interesting account of a visit paid by Dr. Karl Peters last April to some ruins near the river Muira, a southern tributary of the Zambesi, in Portuguese territory, nearly opposite Shupanga. The explorer made his journey in consequence of a passage in the *Atlas Historique*, which is to the effect that half a day's journey from the river Mansoro is the fort of Massapa, and near this is the great mountain of Fura, very rich in gold, in which are Cyclopean ruins. It was to find these ruins that Dr. Peters, accompanied by Mr. Leonard Puzey and Mr. Ernest Gramann, journeyed from the Zambesi. After recounting incidents of the journey, the writer says the decisive discovery for the exploration was made by Mr. Puzey on April 20. The ruins are situated on the hill which runs parallel to Mount Peters, and are about two miles distant from Inja-ka-Fura. Dr. Peters' description of his discovery is as follows: "We discovered . . . another ground-wall which had undoubtedly been a part of a building, maybe a temple, maybe a storehouse. This wall had been worked into the natural rock, which here forms a sort of flat floor. The stones of this ground-wall, samples of which I have sent to London, are heart-shaped, and are worked with a pick, so that the description in our old report saying the stones were not worked with a pick apparently only applies to the outer walls. Perhaps the author never took the trouble to visit one of the ruins. I laid bare a part of this ground-wall on the top, but gave up further digging because I was afraid that my clumsy workmen might do harm to the remains. They have, indeed, already destroyed part of the ground-wall. The stones of the wall are a pseudomorph sandstone, while the rock into which they are worked is quartzitic slate. The whole of the ruin is built after the general ancient Semitic pattern. The Cyclopean wall skirts the hill about halfway between the bottom and the top; on the top the buildings, the hoarding-place, and likely the temple were standing. The remains of a ground-wall along the edge of the top lead me to believe that a second wall formerly ran round the platform itself. To explore the ruin properly it will be necessary to send a scientific expedition with a proper outfit for such excavations. The débris have to be removed, and this I am sure will take a considerable time. Why the old conquerors chose this spot for their fort is easy to see. The Muira touches the bottom of the hill, so water was handy. A second river we have discovered at the back of the ruin. From the top they had an outlook over the wide plain before them, while they had the bulk of the Fura massive at their back. From their fort they commanded the plain as well as the mountain. I have called the hill on which the ruin stands after its discoverer 'Puzey Hill.' Mr. Puzey some days later found a second ruin west-north-west of the first on another head of the same ridge looking over the plain in the same direction. I am certain we shall find still more of these Cyclopean buildings when our time, which now is otherwise occupied, permits of a more extended exploration."

THE *British Central Africa Gazette* for May 24, which has just reached us, says "from time to time it has been rumoured that giraffes existed in British Central Africa, on the Loangwa River, but, although that river valley has been frequently visited during the last ten years by Europeans, no authentic information on the point has ever been obtained. Last month, however, a giraffe was shot on the east bank of the Loangwa in the Marimba district by a European prospector, and its skin (incomplete) sent in to Captain Chichester in Mpezeni's country. The hinder half of the skin is being sent to the British Museum, and it is hoped that a complete specimen may be now obtained. The existence of giraffe in Marimba is remarkable: the area in which they are found is extremely restricted, and their number appears to be very few. The one shot, however, was in a herd of about thirty-five. The nearest country north of Marimba in which giraffe are known to exist is north of Mareres, where the Elton-Cotterill Expedition met with them (many years ago). To the south, Matabeleland is the nearest giraffe country."

THE same number of the *Gazette* states that there seems to be no further decrease in the number of elephants still existing in the Protectorate; indeed, the natives round about Domwe have been complaining to the Acting Collector of the damage done in their food plantations by these animals.

IN the Johns Hopkins University *Circulars* for June 1899 a number of notes from the physical laboratory are published under the editorship of Prof. Joseph S. Ames. These comprise a short paper on the effect of temperature, pressure, and used solutions on the deposit of silver voltameters, by J. F. Merrill; notes on the energy-spectrum of a black body, and on the absorption of ice in the ultra-red, by F. A. Saunders; on the Zeeman effect, by H. M. Reese; on electric absorption in condensers, by L. M. Potts; on transference of heat in cooled metals, and on a method of measuring the frequency of alternating currents, by Carl Kinsley. A list of publications in the department of physics, by those who are now or who have been members of the University, is appended. This list, which represents roughly a year's work, occupies three columns, and includes over ninety works and papers by sixty authors. Similar notes and lists from the department of history and politics also appear in the same number, under the editorship of Prof. Herbert B. Adams.

THE *Berichte der Naturforschenden Gesellschaft* of Freiburg (Baden) contains several papers of interest to physicists. Kathode and Röntgen rays form the subject of a discourse by L. Zehnder, who deals somewhat fully with the theory of fluorescence; Prof. F. Himstedt describes apparatus for illustrating lecture experiments on Hertzian waves and on Marconi's telegraphy, and also writes on point-discharges in high-frequency currents. Of biological interest in the same number are Prof. G. Steinmann's notes on the formation of dark pigment in mollusca, and on *Boueina*—a genus of fossil algæ, and August Grüber's note on green *Amoebae*.

A GOOD work is being done in Italy by the "Valle di Pompei," an institution in the province of Naples for rescuing and educating the children of prisoners and criminals. Apart from the philanthropic aspect of this undertaking, the *Report* contains statistics of interest to anthropologists, criminologists, and those who make a study of heredity. It would appear that under the salutary influence of their environment the children of the worst criminals often take a prominent place in the matter of good conduct and diligence.

THE U.S. Weather Bureau has issued a very useful pamphlet (*Bulletin* No. 26) entitled "Lightning and the electricity of the air," by A. G. McAdie and A. J. Henry. The work is divided into two parts: Part 1 deals with the electrification of the atmosphere and the best methods of protecting life and property from lightning, being to a large extent a revision of *Bulletin* No. 15—"Protection from lightning." Part 2 gives statistics of actual losses of life and property sustained in the United States during 1898. The principal facts of the paper are drawn from articles by the authors in various magazines, with the object of furnishing information of practical value generally, especially to those who may have occasion to seek protection from lightning. The work contains interesting particulars relating to the electrical potential of the upper air, as manifested by kite experiments and auroral displays.

THE Pilot Chart of the North Atlantic Ocean for July, issued by the Hydrographic Office of Washington, contains an article on tropical cyclonic storms or West India hurricanes which are prevalent at this season of the year. From a table showing the number of storms experienced between 1885 and 1898, it is seen that the greater number occur between August and October. The nature and mean path of the hurricanes are exhibited by a diagram. In its earlier stages, the centre of the path of the storm has a certain amount of westing, due to the general westward motion of the atmosphere in the low latitudes in which the storm originates, and the whirl is small, probably less than 100 miles in diameter, but its growth is rapid, so that in the middle and higher latitudes it may attain a diameter of 500 or even 1000 miles. The velocity of progression along the track of the disturbance reaches from twenty to thirty miles an hour in high latitudes, while the velocity of the whirl itself, in a direction against the hands of a watch, attains the force of a hurricane.

THE interesting and useful "Glossary of Popular Local and Old-fashioned Names of British Birds" contained in "A Dictionary of Bird Notes," by Mr. Charles Louis Hett, has been issued separately by Jackson, of Brigg.

THE additions to the Zoological Society's Gardens during the past week include a Bonnet Monkey (*Macacus sinicus*, ♂) from India, presented by Miss Nesta Bevan; a Black-faced Spider Monkey (*Ateles ater*) from Eastern Peru, presented by Mrs. K. E. Mackenzie; two Campbell's Monkeys (*Cercopithecus campbelli*, ♂ ♀) from West Africa, presented by Captain F. R. B. Parmeter; a Mozambique Monkey (*Cercopithecus pygerythrus*) from East Africa, an Arabian Gazelle (*Gazella arabica*) from Arabia, presented by Mr. B. T. Ffinch; two Common Foxes (*Canis vulpes*) from Russia, presented by Mr. A. H. Britten; an Arctic Fox (*Canis lagopus*) from Iceland, presented by Mr. M. Magnusson; five Common Hedgehogs (*Erinaceus europaeus*), European, presented by Mr. Geo. Long; three Chipping Squirrels (*Tamias striatus*) from North America, presented by the Rev. A. E. Tollemache; a Common Peafowl (*Pavo cristatus*, ♂) from India, presented by Miss A. S. Heldmann; two Climbing Anabas (*Anabas scandens*) from India, presented by Mr. P. Burford; two Rheas (*Rhea americana*, white var.) from Argentina, two Syrian Bulbuls (*Pycnonotus xanthopygos*) from Syria, an European Pond Tortoise (*Emys orbiculare*), European, deposited; two Rose-coloured Pastors (*Pastor roseus*), two Indian Mynahs (*Acridotheres ginginianus*) from India, two Bamboo Partridges (*Bambusicola thoracica*) from Northern China, two Lunulated Honey-eaters (*Melithreptes lunulatus*), two Pied Grallinas (*Grallina australis*), two Musky Lorikeets (*Glossopsittacus concinnus*) from Australia, purchased; a Japanese Deer (*Cervus sika*, ♀), born in the Gardens.

## OUR ASTRONOMICAL COLUMN.

TEMPEL'S COMET 1899 *c* (1873 II.).

*Ephemeris for 12h. Paris Mean Time.*

| 1899. | | R.A. h. m. s. | | Decl. ° ′ ″ | | Br. |
|---|---|---|---|---|---|---|
| July 20 | ... | 20 39 34·3 | ... | −18 4 26 | ... | 3·570 |
| 21 | ... | 40 46·1 | ... | 18 37 9 | | |
| 22 | ... | 41 57·9 | ... | 19 10 4 | | |
| 23 | .. | 43 9·5 | ... | 19 43 9 | ... | 3·662 |
| 24 | ... | 44 21·1 | ... | 20 16 22 | | |
| 25 | ... | 45 32·6 | ... | 20 49 38 | | |
| 26 | .. | 46 44·0 | ... | 21 22 55 | | |
| 27 | ... | 20 47 55·4 | ... | −21 56 9 | ... | 3·698 |

HOLMES' COMET 1899 *d* (1892 III.).—Prof. C. D. Perrine gives full details of his rediscovery of the comet in *Astr. Journal*, No. 465. It was found with the 36-inch refractor, using a power of 270. It appeared as a round nebulous mass about 30″ in diameter, with only a slight brightening at the centre. The conditions were good, the sky being very clear and the star images steady. The object was very faint, not brighter than 16 mag., and very difficult to observe, so that the probable error of observation of its place was larger than usual.

DYNAMICAL THEORY OF NEBULÆ.—In No. 465 of the *Astronomical Journal*, Dr. E. J. Wilczynski gives an extended explanation of a dynamical theory of ring and spiral nebulæ which he first brought forward in 1896 (*Astro.-Phys. Journal*, vol. iv p. 97, 1896). He starts with the assumption that the primordial nebula exists either as an assemblage of meteorites or as a gaseous mass obeying the laws of hydrodynamics. Then, in some unexplained way, each particle is to describe a circular orbit about the common centre of gravity, at which point there may or may not be a condensation. Such an arrangement is not necessarily stable, the limit depending on the relative ratios of the masses and distances of the individual particles, and the ratio of the mass of the central controlling body to its distance from the swarm. If these conditions allow stability the body may condense to a star, single or double. If the system be unstable, however, then on applying Kepler's third law to the revolving particles it is found that the inner members, owing to their greater angular velocity, constantly advance with respect to the outer ones, and after an interval the particles originally lying along a *radius* of the swarm will be drawn out into a spiral curve, as is actually the case in the bodies known as spiral nebulæ. According to this view, the *age* of a nebula would be to some extent indicated by the *number of its coils*, and the author gives an interesting suggestion that this might be investigated by a minute comparative examination of all photographs of spiral nebulæ of different dates. The paper concludes by indicating the possibility of determining the *law of rotation* of these bodies by a combination of spectroscopic and photometric observations.

THE NATAL OBSERVATORY.—The annual report of Mr. E. Nevil, Government Astronomer of the Natal Observatory at Durban, consists chiefly of the detailed meteorological observations made at the institution. The staff consists of the director, one senior astronomical assistant, one junior astronomical assistant, and one meteorological assistant. The astronomical equipment includes an 8-inch Grubb equatorial refractor, a 3-inch Troughton and Simms transit instrument, sidereal and mean time clocks, 3-inch portable equatorial refractor, and an automatic signal transmitter and recorder. Owing to a reduction in the vote to the observatory, much of the work has had to be put aside.

The system of time signals established over the Colony has been carried on without alteration, this being facilitated by the erection of new wires. Since the appointment of the astronomer in 1882 there has been no official residence, the computations, &c., having been mostly made in the open air.

This is at last to be remedied by the erection of a residence, all the fixtures, water supply, &c., however, being provided by the astronomer himself.

TEMPERATURE CHANGES IN YERKES OBJECT-GLASS.—Prof. Barnard has several times made series of measures with the large telescope to find if the changes produced in the instrument by variations in temperature were of sufficient amount to necessitate their consideration in delicate investigations. During the last year observations have been made of the focus at temperatures varying from −22° F. to +80° F., the range thus being 102° (*Astr. Journal*, No. 462). The means of the observations made on nineteen nights show a marked difference in the focus, and it was found that the object-glass shortened 0·26 inch more than the steel tube which carried it. Micrometric measures of the difference in declination between the stars *Atlas* and *Pleione* of the Pleiades showed a decrease of nearly 0″·2 (from 0″·676 during July–September to 0″·491 during January–February).

From the result of these experiments Prof. Barnard thinks that for exact work, such as parallax, with a large glass in a variable climate, these minute changes ought to be determined and taken into account.

In addition to these visual observations, careful determinations of the changes in the colour-curve during wide extremes of temperature are being carried on by Prof. Frost and Mr. Ellerman.

## *THE REASON FOR THE HISSING OF THE ELECTRIC ARC.*[1]

HISSING is one of the few phenomena connected with the electric arc with which every one is more or less familiar. In the old days the sudden, almost complete, extinction of the light of an arc-lamp, and the loud hiss accompanying its relighting, was so common an occurrence that it was supposed by the lay mind to form part and parcel of the working of the "electric light," and led to a lively prejudice against that light on the part of the public. In these days of enclosed arcs and of better constructed lamps, such little interludes are of far less frequent occurrence; but it is as important as ever, from a scientific point of view, to discover their origin, and even from the practical side anything which points to a remedy for this grave defect in arc-lighting cannot fail to be of interest.

The object of the present article is to explain the cause of hissing in direct current open arcs; that is to say, in arcs in which the current flows always in one direction, and to which the air has free access at every point.

a sound something like that of steam under pressure, issuing from a pipe. This sound is accompanied by a diminution of about ten volts in the P.D., or electric pressure between the carbons, and an increase in the current.

For the experiments on which the present article was based, three sets of electrical measurements were made, viz. measurements of the current, the P.D. between the carbons, and the length of the arc. Before each observation was made the current and length of arc were kept *rigorously* constant for a sufficient length of time for the carbons to take their characteristic shape for that particular current and length of arc, and long enough, therefore, for the P.D. to have become constant also. Such an arc is called a *normal* arc, as contrasted with one arrived at in a haphazard fashion by suddenly giving the current some particular value and the arc some particular length, and making observations without allowing time for the carbons to acquire their proper forms.

The carbons used were generally both *solid*, that is, neither had a soft core such as is usually given to the positive carbon when the arc is employed for lighting purposes, and they were,

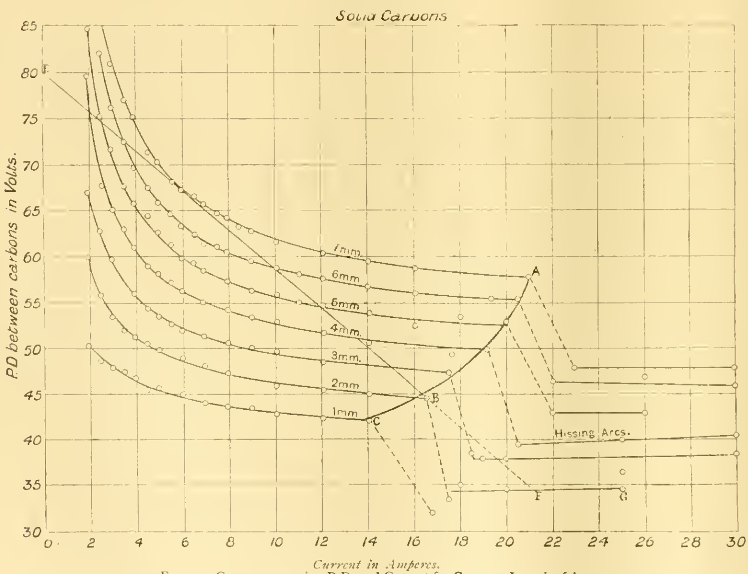


FIG. 1.—Curves connecting P.D. and Current for Constant Length of Arc.

Carbons:—Positive, 11 mm.; Negative, 9 mm.

There are other ways in which a change taking place in the arc may manifest itself, in addition to giving out sounds of various kinds or by becoming silent. For example, there may be changes in its electrical measurements, or an alteration in the appearance of the crater, the arc, and the carbons.

The sounds given out by the *direct current open* arc are many and various, but only two seem to possess much significance—the hum and the hiss—and the causes of these are evidently connected with one another, for the hum never occurs except when the arc is on the point of hissing or has just been hissing, although it is quite possible to make an arc hiss and become silent again without any hum being heard either before or after.

The hum is a distinct musical note, which is often quite low to start with, and gets higher and higher, till it finally rises to a shriek, and then the arc breaks into a loud hiss, giving forth

[1] Based on a paper read before the Institution of Electrical Engineers by Mrs. W. E. Ayrton.

as usual, placed vertically over one another with the positive carbon on top.

Some of the results of these experiments are given in Fig. 1, in which the curves connect the P.D. between the carbons with the current, for various constant lengths of arc. Starting from the left, each curve goes smoothly on its way, as the current increases, till a certain point is reached, when it suddenly breaks down, and is continued in a straight line far below and to the right of its own lowest point. The break-down occurs when the current has such a value that the arc can no longer remain silent. The dotted lines, which join the *curves* for silent arcs to the *straight lines* for hissing arcs of the same length, indicate ranges of current that will not flow through the particular length of arc indicated at all if the arc is normal with the arrangement of the circuit existing when the experiments were made.

An examination of these curves shows that with the carbons used, and with the *normal* arc, the following results are met with:

(1) When the length of the arc is constant and the arc is silent, it may be made to hiss by increasing the current sufficiently.

OPEN ARCS.

*Positive Carbon Cored.*

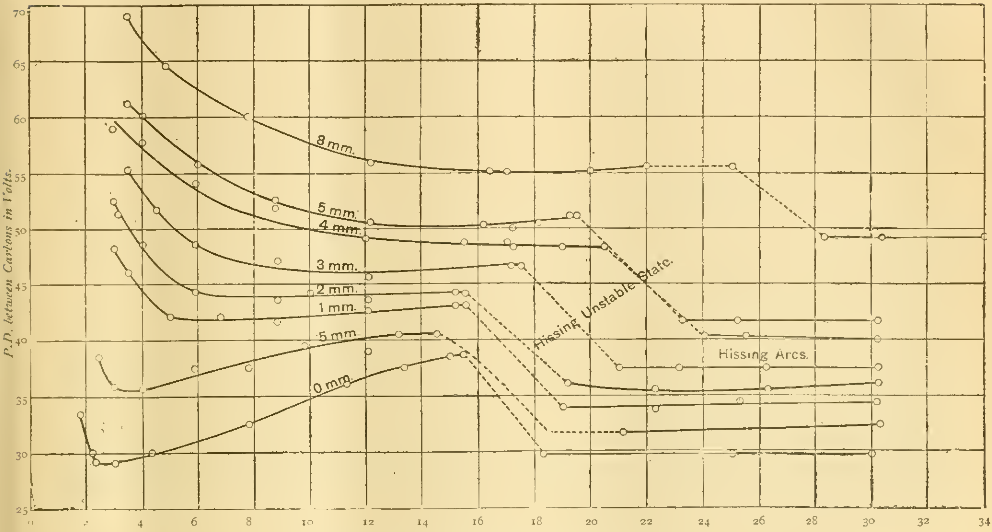


FIG. 2.—Curves connecting P D. and Current for Constant Lengths of Arc. Carbons:—Positive, 9 mm. Cored.; Negative, 8 mm. Solid.

(2) When the current is constant and the arc is silent, *shortening* the arc will make it hiss.

(3) The largest current that will maintain a *silent* arc is greater the longer the arc.

OPEN ARCS.

*Positive Carbon Cored.*

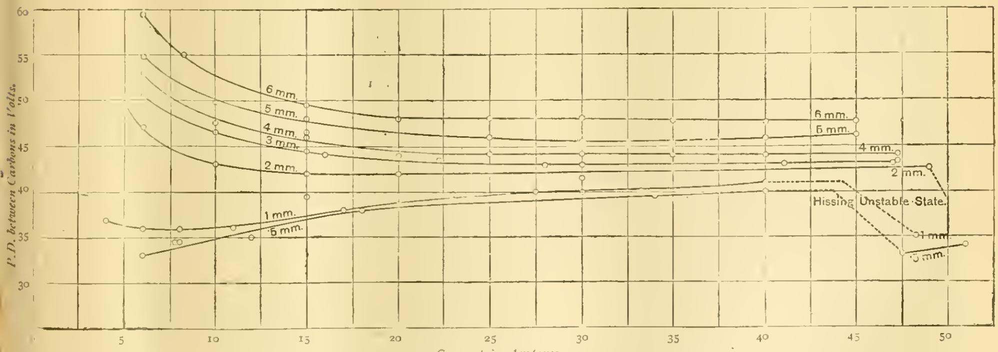


FIG. 3.—Curves connecting P.D and Current for Constant Lengths of Arc Carbons:—Positive, 18 mm. Cored.; Negative, 15 mm. Solid.

(4) When the arc begins to hiss, the P.D. suddenly falls about 10 volts and the current suddenly rises two or three amperes.

(5) For the hissing arc the P.D. is constant for a given length of arc, whatever the current.

It was Niaudet (*La Lumière Electrique*, 1881, vol. iii. p. 287) who, in 1881, first observed the fall of about 10 volts in the P.D. between the carbons at the moment hissing began, and, although perhaps there is even yet a lingering notion that it is only when an arc is short that it can hiss, I find that as far back as 1889 Luggin (*Wien Sitzungsberichte*, 1889, vol. xlvii. p. 118) showed that, however long an arc might be, it would still hiss were the current increased sufficiently.

At the Congress at Chicago in 1893 Prof. Ayrton (*The Electrician*, 1895, vol. xxxiv. pp. 336–7) first drew attention to the region of instability indicated by the dotted portions of the curves. At the same time he pointed out in Fig. 2, shown at Chicago, that whether the P.D. was descending as the current increased for, say, a 4 mm. arc, or was ascending for, say, a 0·5 mm. arc, it became quite constant for wide variations of current with a hissing arc.

And, lastly, by a comparison of Fig. 2 with Fig. 3 he brought out the fact that the largest current that would flow silently with any given length of arc was increased by using thicker carbons; for the carbons in Fig. 3 have about twice the diameter of those in Fig. 2, and while the largest silent current for, say, the 2 mm. arc in Fig. 2 is 15·5 amperes, that for the same length of arc in Fig. 3 is about 49 amperes, or more than three times as great.

Returning now to the subject of the dotted lines in Figs. 1, 2 and 3, it is plain that these divide the curves into two perfectly separate parts, governed by different laws. For to the left of the dotted part the lines are all curved, and curved differently according as *solid* positive carbons are used as in Fig. 1, or *cored* as in Figs. 2 and 3, showing that with silent arcs the P.D. varies as the current varies, and that the law of variation is different with solid and cored carbons. To the right, on the other hand, the lines are all straight, and more or less parallel to the axis of current, whether the positive carbon is solid or cored, showing that with *hissing* arcs the P.D. is the same for a given length of arc and a given pair of carbons, *whatever* current is flowing, and that this law is true whether the carbons be cored or solid. In fact, when the arc begins to hiss some complete and sudden break down appears to occur, upsetting all the laws that have governed it while it was silent, and making cored and solid carbons behave alike.

Thus, our subject divides itself quite naturally into two distinct portions, the one dealing with the arc when the break-down is imminent, but before it has actually occurred—dealing, that is to say, with the points at which the current is the largest that will flow silently—the *hissing points* as I shall call them; and the other dealing with the arc after the break-down has occurred, and when, therefore, the arc is really hissing.

An examination of Fig. 1 shows that the hissing points lie well on the curve A B C; that curve may, therefore, be taken to embody the laws connecting the P.D. between the carbons, the current, and the length of the arc, at the *hissing points*, for at least all those lengths of arc given by the curves in Fig. 1. The most important of these laws concerns the current at the *hissing point*, the largest *silent* current.

It is quite plain, from Fig. 1, that although this current increases as the length of the arc increases, yet it does not increase at the same rate as the length of the arc. For each millimetre added to the length of the arc involves a smaller and smaller addition to the largest silent current; so that finally a current must be reached which will not increase appreciably however much the arc is lengthened, always supposing that the law continues to hold for such long arcs. Hence, on this supposition, *for each pair of carbons the current that will sustain a normal silent arc has a maximum value, and any current greater than this will make the arc hiss, however long it may be.*

Other laws concerning the arc when on the point of hissing and when actually hissing can be deduced directly from Figs. 1, 2 and 3, but as these do not bear directly on the *cause* of hissing, the mathematical proofs of them may with advantage be omitted from the present article. Some of these laws may, however, be summed up as follows:—

If V be the P.D. in volts between the carbons at the hissing point for an arc of $l$ millimetres, and if V′ be the constant P.D. between the carbons for a hissing arc of the same length, then

$$V = 40{\cdot}05 + 2{\cdot}49\, l,$$
$$V' = 29{\cdot}25 + 2{\cdot}75\, l,$$

and consequently

$$V - V' = 10{\cdot}8 - 0{\cdot}26\, l,$$

which shows that *the longer the arc the less is the P.D. between the carbons diminished when it changes from silence to hissing.*

The numerical coefficients in the above equations naturally refer only to the carbons I used in my experiments, but the *laws* expressed by the equations must be true for *all* direct current open arcs of lengths not differing very greatly from those I used, and burning between solid carbons.

From Fig. 1 it might be supposed that, given the length of the arc, the increase of current that abruptly occurs on the arc starting hissing was as definite for that length of arc as the diminution in the P.D. And this, for a long time, I imagined to be the case. But while trying to find out what law connected the smallest hissing current with the length of the arc, I saw that the value of that current really depended on the circuit *outside* the arc. I found, in fact, that when the largest silent current for any length of arc changes to the smallest hissing current for the *same* length of arc, the value of that smallest hissing current depends on the E.M.F. of the dynamo *only*. The smaller that E.M.F. is, the greater will be the smallest hissing current for any given length of arc, while if the E.M.F. of the dynamo could be made infinite, the smallest hissing current and the largest silent current would be equal; that is to say, when the arc began to hiss the P.D. between the carbons would drop, but the current would remain quite unchanged.

Thus it is possible, by choosing suitable E.M.F.s, to make the sudden smallest hissing current have any value greater than that of the largest silent current for the same length of arc.

In 1889 Luggin found, by measuring the fall of potential between each carbon and the arc, that the principal part of the diminution of P.D. caused by hissing took place at the junction of the positive carbon and the arc. Some experiments of the same sort that I made about three years ago, using arcs varying between 1 mm. and 6 mm., gave the same result.

For the lengths of arc dealt with, I found that hissing caused a mean fall of about 9·7 volts in the total P.D. between the carbons, and a mean fall of about 6·3 volts in the P.D. between the positive carbon and the arc. Hence of the whole diminution of the P.D. between the carbons caused by hissing, about two-thirds took place at the junction of the positive carbon and the arc.

Further, my experiments showed that very little of the remainder of the diminution, if any, was due to a diminished fall in the P.D. between the arc and the negative carbon; therefore this remaining diminution must be attributed to a lowering of the resistance of the arc itself. We may sum up these results as follows:—

*Of the total diminution of the P.D. between the carbons caused by hissing, about two-thirds takes place at the junction of the positive carbon and the arc, and the remaining third seems to be due to a lowering of the resistance of the arc itself.*

We now pass from the consideration of the electrical measurements of the arc to the appearance of the crater, arc, and carbons.

Every alteration of the current and of the distance between the carbons naturally produces a corresponding modification of all parts of the arc, but until the value of the current attains a certain magnitude, which depends only on the length of the arc with a given pair of carbons, this change is one of degree merely, and not of character. A greater current simply produces a larger crater, a larger arc, and longer points to the carbons. When the special current is reached, however, a change, which is no longer simply one of degree, takes place in that white-hot depression at the end of the positive carbon from which most of the light of the arc is derived—the crater, as it is called. Instead of presenting a uniformly bright surface to the eye, this becomes partly covered with what appear to be alternately bright and dark bands, sometimes radial like the spokes of a wheel, sometimes in one or more sets of concentric circles, sometimes oscillating, sometimes rotating round different centres in opposite directions. The directions of rotation or oscillation and whole positions of the images change continually, and the motion grows faster and faster as the current is increased.

When the current is so much increased that the motion becomes too fast for the eye to detect, the arc begins to hum, and then, as Mr. Trotter (*Proc. Roy. Soc.*, vol. lvi. p. 262) first showed in 1894, it rotates at the rate of from 50 to 450 revolutions per second.

As soon as hissing begins the whole appearance of the crater changes again; a sort of cloud seems to draw in round a part of it, moving from the outer edge inwards, and varying continually in shape and position. Sometimes but one bright spot is left, sometimes several, but always the surface is divided into bright and dull parts, giving it a mottled appearance, as is slightly indicated in (*b*) Fig. 4. If, then, the current be diminished, so that the arc becomes silent again, the whole

surface of the crater grows dark for an instant, then brightens in spots, and finally becomes bright again all over.

The vaporous arc itself undergoes fewer modifications; it preserves the ordinary characteristics of the silent arc while rotating wheels hold possession of the crater, but, when humming begins, a green light is seen to issue from the crater, and with hissing this becomes enlarged and intensified, till the whole centre of the purple core is occupied by a brilliant greenish-blue light, as is indicated in Fig. 5.

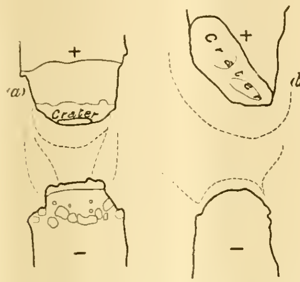


FIG. 4.—Carbons: Positive, 9 mm Cored; Negative, 8 mm Solid. Length of Arc. (a) 5 mm., (b) 8 mm. Current (a) 3·5 amperes, (b) 34 amperes.

M. Blondel, whose accuracy of observation and originality in experiment have added so much to our knowledge of the arc, first mentioned a very curious fact about this vapour in 1893 (*The Electrician*, 1893, vol. xxxii. p. 170). He noticed that, while the arc was silent, the vapour was quite transparent, so that, when viewed at a proper angle, the crater could be seen through it perfectly; but that, as soon as hissing began, the vapour became so opaque as to completely hide the crater.

In any case, however, M. Blondel's theory of a change from vapour to solid particles in the arc when hissing begins seems to me to be hardly tenable, if only for the following reason. Whenever we put solid carbon into the arc, such, for instance, as a very thin carbon rod, it glows far more brilliantly than the surrounding vapour, and hence increases the luminosity of the arc. If, therefore,

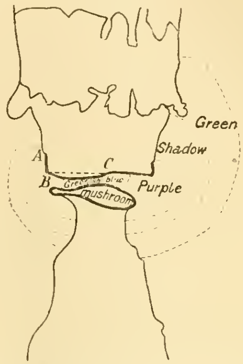


FIG. 5.—Carbons:—Positive, 11 mm. Solid; Negative, 9 mm. Solid. Length of Arc, 1·5 mm. Current, 28·5 amperes.

hissing is accompanied by a substitution of solid particles for the vapour of the arc, the luminosity of the arc should *increase* with hissing. But, M. Blondel mentions, in the same article, that the intrinsic brilliancy of the arc *diminishes* when hissing begins, hence the theory of a disruptive discharge of solid particles does not appear to cover the facts.

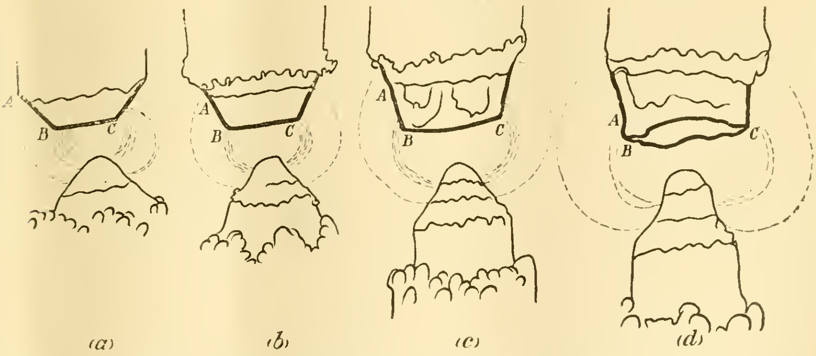


FIG. 6.—Carbons:—Positive, 11 mm. Solid; Negative, 9 mm. Solid. Length of Arc, 2 mm. Current, (a) 6 amperes, (b) 12 amperes, (c) 20 amperes, (d) 30 amperes.

M. Blondel believes that, when hissing begins, the gentle evaporation of the carbon of the crater, which feeds the column of vapour in the silent arc, gives place to a disruptive discharge of solid particles torn from the crater.

I have found the opacity of the hissing arc less complete and less invariable than M. Blondel, probably because my conditions were different from his. Indeed I have often been able to see the crater of a hissing arc through the vapour as clearly as if the arc were silent.

The *shape* of the arc also alters when hissing begins. When the arc is silent its shape is rounded, and it has an appearance of great stability; but as soon as hissing occurs, it seems suddenly to dart out from between the carbons and to become flattened out, as if under the influence of a centrifugal force acting at right angles to the common axis of the two carbons. In Fig. 5 and in (*d*) Fig. 6, this flattened appearance is well marked; and indeed these figures show that every part of the vaporous arc itself is involved in this flattening—the purple core,

the shadow round it, and the green aureole—as if they were all revolving with great rapidity round a common axis. And what more likely than that this should be the case, since, as has already been mentioned, the arc is revolving at the rate of 450 revolutions per second *at the moment that it starts hissing?*

As regards the carbons themselves, the only important modification of the *negative* carbon that appears to be due to hissing is the formation of the well-known "mushroom" at the end of that carbon with a *short* hissing arc. This mushroom, of which a good example is seen in Fig. 5, is well named, not only because of its shape, but also because of the rapidity of its growth, which is so great that, while it is forming, the carbons often have to be *separated*, instead of being *brought together*, to keep the length of the arc constant.

(*To be continued.*)

## HYBRIDISATION.[1]

OUR first duty, and a very pleasant one it is, is to welcome our foreign guests, our friends from across the sea, as I prefer to call them, to thank them for their presence here to-day, and to express a hope that their sojourn among us may be both agreeable and profitable. At the same time we regret that some, such as Dr. Focke, the historian of hybridisation, has not been able to preside over this meeting, as we had hoped he might have done. Nor can we at such a meeting do other than express our abiding regret at the loss, though at an advanced age, of the great hybridiser Charles Naudin.

Our next duty is to thank the Council of the Royal Horticultural Society for this opportunity of meeting once more in these time-honoured gardens to discuss what I venture to think is one of the, if not the most, important subject in modern progressive experimental horticulture. I use the words progressive and experimental because I believe that the future of horticulture depends very greatly on well-directed experiment.

So far as the details of practical cultivation are concerned, we are not so much in advance of our forefathers. We have infinitely greater advantages, and we have made use of them, but if they had had them they would have done the same. We are able to bring to bear on our art not only the "resources of civilisation" to a degree impossible to our predecessors, but we can avail ourselves also of the teachings of science, and endeavour to apply them for the benefit of practical gardening. We are mere infants in this matter at present, and we can only dimly perceive the enormous strides that gardening will make when more fully guided and directed by scientific investigations. One object of this conference is to show that cultural excellence by itself will not secure progress, and to forward this progress by discussing the subject of cross-breeding and hybridisation in all their degrees, alike in their practical and in their scientific aspects.

To appreciate the importance of cross-breeding and hybridisation we have only to look round our gardens and our exhibition-tents, or to scan the catalogues of our nurserymen. Selection has done and is doing much for the improvement of our plants, but it is cross-breeding which has furnished us with the materials for selection.

A few years ago by the expression "new plants" we meant plants newly introduced from other countries, but, with the possible exception of orchids, the number of new plants of this description is now relatively few.

The "new plants" of the present day, like the roses, the chrysanthemums, the fuchsias, and so many others, are the products of the gardeners' skill. From peaches to potatoes, from peas to plums, from strawberries to savoys, the work of the cross-breeder is seen improving the quality and the quantity of our products, adapting them to different climates and conditions, hastening their production in spring, prolonging their duration in autumn.[2] Surely in these matters we have outdistanced our ancestors.

But let us not forget that they showed us the way. I do not propose to dilate on the share which Camerarius, Millington, Grew, Morland, and others, at the close of the seventeenth century had in definitely establishing the fact of sexuality in plants, but I do wish to emphasise the fact that it was by experiment, not by speculation, nor even by observation, that the fact was proved, and I do wish to show that our English gardeners and experimenters were even at that time quite aware of the importance of their discovery, and forestalled our Herbert and Darwin in the inferences they drew from it. In proof of which allow me to quote from a work of Richard Bradley, called "New Improvements of Planting and Gardening, both Philosophical and Practical," published in 1717, cap. ii. After alluding to the discovery of the method of the fertilisation of plants, he says (p. 22):—

"By this knowledge we may alter the property and taste of any *Fruit* by impregnating the one with the *Farina* of another of the same class; as, for example, a *Codlin* with a *Pearmain*, which will occasion the *Codlin* so impregnated to last a longer time than usual, and be of a sharper taste; or if the *Winter Fruits* should be fecundated with the *Dust* of the *Summer kinds*, they will decay before their usual Time; and it is from this accidental coupling of the *Farina* of one with the other, that in an *Orchard* where there is Variety of *Apples*, even the *Fruit* are gathered from the same *Tree* differ in their Flavour and Times of ripening; and, moreover, the *Seeds* of those Apples so generated, being changed by that Means from their Natural Qualities, will produce different kinds of Fruit if they are sown.

"'Tis from this accidental coupling that proceeds the numberless varieties of Fruits and Flowers which are raised every day from *Seed*. . . .

"Moreover, a curious Person may by this knowledge produce such rare kinds of *Plants* as have not yet been heard of, by making choice of two *Plants* for his Purpose, as are near alike in their Parts, but chiefly in their *Flowers* or *Seed* vessels; for example, the Carnation and Sweet William are in some respects alike, the *Farina* of the one will impregnate the other, and the *Seed* so enlivened will produce a *Plant* differing from either, as may now be seen in the garden of Mr. *Thomas Fairchild*, of *Hoxton*, a plant neither *Sweet William* nor *Carnation*, but resembling both equally, which was raised from the *seed* of a Carnation that had been impregnated by the *Farina* of the Sweet William."

Here we have the first record of an artificially-produced hybrid, and you will remark that this was more than forty years before Kolreuter began his elaborate series of experiments. Fairchild was the friend and associate of Philip Miller, and of a small knot of advanced thinkers and workers who banded themselves together into a "Society of Gardeners."

"He is mentioned," says Johnson in his "History of English Gardening," "throughout Bradley's works as a man of general information, and fond of scientific research, and in them are given many of his experiments to demonstrate the sexuality of plants, and their possession of a circulatory system. He was a commercial gardener at Hoxton, carrying on one of the largest trades as a nurseryman and florist that were then established. He was one of the largest English cultivators of a vineyard, of which he had one at Hoxton as late as 1722. He died in 1729, leaving funds for insuring the delivery of a sermon annually in the church of St. Leonard's, Shoreditch, on Whit Tuesday, 'On the wonderful works of God in the Creation; or On the certainty of the resurrection of the dead, proved by the certain changes of the animal and vegetable parts of the creation.'"

Fairchild was thus not only the raiser of the first garden hybrid, but the originator of the flower services now popular in our churches.

We do not hear much of intentionally-raised hybrids from this time till that of Linnæus, in 1759 ("Amœn. Acad.," ed. Gilibert, vol. i. p. 212). The great Swedish naturalist, having observed in his garden a Tragopogon, apparently a hybrid between *T. pratensis* and *T. parvifolius*, set to work to ascertain whether this conjecture was correct. He placed pollen of *T. parvifolius* on to the stigmas of *T. pratensis*, obtained seed, and from this seed the hybrid was produced.

About the same time (that is, in 1760) Kolreuter began his elaborate experiments, but these were made with no practical aim, and thus for a time suffered unmerited oblivion.

Some years after, the President of this Society, Thomas

[1] Substance of the address by Dr. Maxwell T. Masters, F.R.S., delivered on opening the proceedings of the International Conference on "Hybridisation," Tuesday, July 11.

[2] See some interesting observations of MacFarlane on the period of flowering in hybrids as intermediate between that of the parents, *Gardeners' Chronicle*, June 20, 1891; and on the structure of hybrids, May 3, 1890.

Andrew Knight, and especially Dean Herbert, took up the work, with what splendid results you all know.

It is curious, however, to note that objections and prejudices arose from two sources. Many worthy people objected to the production of hybrids, on the ground that it was an impious interference with the laws of nature. To such an extent was this prejudice carried, that a former firm of nurserymen at Tooting, celebrated in their day for the culture, amongst other things, of heaths, in order to avoid wounding sensitive susceptibilities, exhibited as new species introduced from the Cape of Good Hope forms which had really been originated by cross-breeding in their own nurseries.

The best answer to this prejudice was supplied by Dean Herbert, whose orthodoxy was beyond suspicion. He, like Linnæus before him, had observed the existence of natural hybrids, and he set to work experimentally to prove the justness of his opinion. He succeeded in raising, as Engleheart has done since, many hybrid narcissi, such as he had seen wild in the Pyrenees, by means of artificial cross-breeding. If such forms exist in nature, there can be no impropriety in producing them by the art of the gardener.

In our own time, Reichenbach, judging from appearances, described as natural hybrids numerous orchids. Veitch and others have confirmed the conjecture by producing by artificial fertilisation the very same forms which the botanist described.

It remains only to speak of another respectable but mistaken prejudice that has existed against the extension of hybridisation. I am sorry to say this has been on the part of the botanists. It is not indeed altogether surprising that the botanists should have objected to the inconvenience and confusion introduced into their systems of classification by the introduction of hybrids and mongrels, and that they should object to hybrid species, and much more to hybrid genera; but it would be very unscientific to prefer the interests of our systems to the discovery of the truth.

I may mention two cases where scepticism still exists as to the real nature of certain plants: *Clematis jackmani* of our gardens, raised, as is alleged, by Mr. Jackman, of Woking (*Gardeners' Chronicle*, 1864, p. 825), was considered by M. Decaisne and M. Lavallée [1] to be a real Japanese species, and not a hybrid. This may be so, but there is no absolute impossibility in the conjecture that the Japanese plant and the cultivated plant originated in the same way. Again, Mr. Culverwell's supposed hybrid between the strawberry and the raspberry has been pronounced to be no hybrid, but to be *Rubus leesii*. But what, we may ask, is *Rubus leesii?* It appears to be a sterile form more closely allied to the raspberry than to the strawberry. Is it not at least possible that Mr. Culverwell has produced it artificially?

The days when "species" were deemed sacrosanct, and "systems" were considered "natural" have passed, and Darwin, just as Herbert did in another way, has taught us to welcome hybridisation as one means of ascertaining the true relationships of plants and the limitations of species and genera.

Darwin's researches and experiments on cross-fertilisation came as a revelation to many practical experimenters, and we recall with something akin to humiliation the fact that we had been for years exercising ourselves about the relative merits of "pin eyes" and "thrum eyes" in primroses, without ever perceiving the vast significance of these apparently trifling details of structure.

It would occupy too much time were I to dilate upon the labours of Gaertner, of Godron, of Naudin, of Naegeli, of Millardet, of Lord Penzance, of Engleheart, and many others. Nor need I do more than make a passing reference to the wonderful morphological results obtained by the successive crossings and inter-crossings of the tuberous begonias, changes so remarkable that a French botanist was even constrained to found a new genus, Lemoinea, so widely have they deviated from the typical begonias.

For scientific reasons, then, no less than for practical purposes, the study of cross-breeding is most important, and we welcome the opportunity that this conference affords of extending our knowledge of the life-history of plants, in full confidence that it will not only increase our stock of knowledge, but also enable us still further to apply it to the benefit of mankind.

[1] Lavallée, "Les Clematites à Grandes Fleurs," p. 6 and p. 9, tab. iv.: *Clematis hakonensis.*

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

DR. A. C. HOUSTON has been appointed Lecturer in Bacteriology at Bedford College, London, for Women.

Dr. W. WACE CARLIER, at present Lecturer on Experimental Physiology and Histology in the University of Edinburgh, has been appointed Professor of Physiology in Mason University College, Birmingham.

THE Royal Commissioners for the Exhibition of 1851 have approved the nomination by the University College of North Wales of Mr. Robert Duncombe Abell to a Science Research Scholarship of the value of 150*l.* a year. Mr. Abell is about to enter the University of Leipzig, where he proposes to engage in a special research under the direction of Prof. Wislicenus.

THE following appointments abroad may be noticed:—Dr. James Ewing to be professor of pathology in the Cornell University Medical College; Dr. Charles W. Wardner to be professor of physics in Williams College; Dr. H. G. Byers to be professor of chemistry in the State University of Washington; Dr. Alfred H. Seal to be professor of chemistry in Girard College, Philadelphia.

THE new buildings of the London Hospital Medical College were opened on Tuesday last. They occupy the site of the old chemical theatre and laboratory, and comprise the following rooms and departments. On the basement is the department of public health, containing a large museum, professors' room, class rooms, &c.; on the ground floor, the biological laboratory, class rooms, and the materia medica museum; on the first floor, the chemical theatre and laboratories, and the balance room; on the second floor, the physics laboratory, the chemical laboratory for the diploma in public health classes, the operative surgery room, and a large anatomy class room leading from the dissecting room. On the third floor is the bacteriological department, with general laboratory, research laboratories, class rooms for public health work, sterilising room, &c. Other portions of the building have thus been left for additional development, and advantage has been taken of this to provide special class rooms for students studying for the preliminary scientific, the intermediate M.B., London, and other examinations. Additions have also been made to the present physiological department, giving rooms for original research and for special class work for the higher examinations. For all these departments special teachers have already been appointed, who are devoting their entire time to the particular subjects that they have undertaken. The new buildings, with their fittings, will cost altogether not less than 10,000*l.*

## SCIENTIFIC SERIAL.

*Bollettino della Società Sismologica Italiana*, vol. v. No. 1, 1899–1900.—The rules of the Society and list of Fellows (forty-three national and ten foreign) are given.—Determination of the epicentre and time at the origin of earthquakes of unknown origin propagated along the earth's surface by means of four or five time-observations, by G. Costanzi. Equations for the above purposes are obtained on the supposition that the surface-velocity is constant.—Vesuvian notices (July–December 1898), by G. Mercalli. A monthly chronicle, with notes on the paroxysm of September, the central crater, and the excentric eruptive apparatus; illustrated by reproductions of two photographs.—Notices of the earthquakes observed in Italy (January 1–February 3, 1898), by G. Agamennone, the most important being the Ferrara earthquake of January 16, a distant earthquake on January 25, and the Asia Minor earthquake of January 29.

## SOCIETIES AND ACADEMIES.

### LONDON.

Royal Society, June 15.—"On the Application of Fourier's Double Integrals to Optical Problems." By Charles Godfrey, B.A.

The disturbance received at any point from a luminous body is a vector, varying with the time. It may be defined by its resolved parts along three rectangular axes; let $f(t)$ be one of these resolutes. In general $f(t)$ will not be a periodic function,

even when the light is approximately monochromatic. By Fourier's theorem of double integrals

$$f(t) = \int_0^\infty (C \cos ut + S \sin ut) \, du,$$

where

$$C = \frac{1}{\pi} \int_{-\infty}^{+\infty} f(v) \cos uv dv, \quad S = \frac{1}{\pi} \int_{-\infty}^{+\infty} f(v) \sin uv dv.$$

This is true provided $f(t)$ is subject to certain conditions, which are proved to be present in any physical problem. The object of the paper is to inquire whether the above theorem justifies us in regarding any plane-polarised plane light motion as equivalent to a combination of simple harmonic vibrations, with periods varying from 0 to $\infty$. The element of the integral suggests a vibration of amplitude $du \sqrt{C^2 + S^2}$, phase $\tan^{-1}\frac{S}{C}$, and period $\frac{2\pi}{u}$. It is proved that in certain very general cases such an interpretation is possible, notably in the case of "constant" light, such as presents a steady appearance.

This calculus enables us to discuss the width of the lines in the spectrum of an incandescent gas, taking into account not only the velocities of the molecules, but also the effect of collisions, and of radiative damping in the molecular vibrations. The connection between Röntgen rays and ordinary light is examined, J. J. Thomson's theory of the former being assumed. It is shown that perhaps $\frac{1}{1000}$ of the energy of the rays will be in the visible spectrum. The theory of dispersion is considered with reference to natural light as opposed to a simple harmonic train of waves.

### PARIS.

**Academy of Sciences**, July 10.—M. van Tieghem in the chair.—The Perpetual Secretary announced to the Academy the loss it had sustained by the death of Sir William Flower, Correspondent in the Section of Anatomy and Zoology.—Remarks by M. Ed. Perrier on his *Traité de Zoologie*.—New researches on argon and its combinations, by M. Berthelot. Having a larger quantity of argon placed at his disposal, the author has repeated his earlier observations on the reactions between argon and certain organic compounds. Entirely negative results were obtained when mixtures of argon with ethylene, glycollic ether, aldehyde, acetone, amylene, petroleum ether, propionitrile, allyl sulphocyanide, or amylamine were submitted to the prolonged action of the silent discharge, the original volume of argon being recovered unchanged. With benzene, toluene, cymol, turpentine, anisol, phenol, benzaldehyde, aniline, phenyl sulphocyanide, and benzonitrile, on the other hand, an absorption of argon took place in amounts varying from one to six per cent. At the same time a greenish fluorescence appeared, giving a characteristic spectrum.—On the geographical and cartographical work carried out in Madagascar by order of General Gallieni between 1897 and 1899, by M. Alfred Grandidier. The values previously assumed for the latitude and longitude of Tamatave, Andévorante, Fort Dauphin, and other towns in Madagascar are here revised, and the differences tabulated.—On the dialkylbenzoylbenzoic acids and their tetra-chlor-derivatives, by MM. A. Haller and H. Umbgrove. Details are given of the preparation and properties of tetrachlordimethylamidobenzoylbenzoic acid, acetyldimethylamidobenzoyltetrachlorbenzoic anhydride and the corresponding ethyl and methyl ethers, dimethylamidobenzoyltetrachlorbenzoic acid and the anhydride of acetyldiethylamidobenzoyltetrachlorbenzoic acid, together with its ethyl and methyl ethers.—On the development of analytical functions of several variables, by M. Paul Painlevé.—Contribution to the theory of musical instruments, by M. Firmin Larroque.—Remarks on the use of cryohydrates, by M. A. Ponsot.—Action of nitric oxide upon chromous salts, by M. Chesnau. Chromous salts in solution dissolve nitric oxide like ferrous salts, giving only one compound. On heating, or placing in a vacuum, this compound gives off no gas, thus differing from the corresponding ferrous compound.—On metallic sulphantimonites, by M. Pouget. Solutions of potassium sulphantimonites by double decomposition with salts of metals may give salts of the types $SbS_3M_3$, or $SbS_3M_2K$, but in no case of the type $SbS_3MK_2$.—Action of phenylhydrazine upon alcoholic bromides, chlorides, and iodides, by M. J. Allain Le Canu. The iodides behave differently to the corresponding bromides and chlorides in respect to their reaction with phenylhydrazine.—On the aminocampholenes, by MM. E. E. Blaise and G. Blanc.—Contribution to the study of an oxyptomaine, by M. Œchsner de Coninck. The oxyptomaine $C_8H_{11}NO$ was prepared by the action of hydrogen peroxide upon the pyridic ptomaine, $C_8H_{11}N$. In the present paper details are given of its bromohydrate, chloroaurate, and chloromercurate.—New method for the acidimetric estimation of alkaloids, by M. Élie Falières. The titration is conducted with an ammoniacal copper solution instead of litmus or one of the ordinary indicators. The experimental results were very satisfactory.—On benzoyl-furfurane, by M. R. Marquis. Benzoylfurfurane is readily obtained by the interaction of pyromucyl chloride and benzene in presence of aluminium chloride.—The egols, new general antiseptics, by M. E. Gautrelet. Parasulphones derived from phenols are nitrated, and the ortho-nitro-phenolparasulphonate of mercury and potassium prepared from this. The compounds thus obtained are termed egols, phenegol from phenol, cresegol from cresol, and so on, and possess certain advantages as antiseptic agents.—The *rôle* of heat in muscle action, by M. Raphael Dubois.—New observations on echidnase, by M. C. Phisalix. This ferment is present in snake poison, and is found to exert a diastatic action not only upon animal tissues, but even upon the active principle of snake poison, echidnotoxin.—Analogies between cultures of the vegetable fungus *Nectria* and the parasitic fungus in human cancer, by M. Bra.—On the absence of regeneration of the posterior members of the leaping Orthoptera and its probable causes, by M. Edmond Bordage.—On the affinities of *Microsporum*, by MM. L. Matruchot and Ch. Dassonville.—On the cicatrisation of the fascicular system, and of the secretory apparatus on the falling of the leaf, by M. A. Tison.—Barometric deviations on the meridian of the sun at successive days of the synodic revolution, by M. A. Poincaré.—On the use of self-recording meteorological apparatus in captive balloon ascents, by M. Léon Teisserenc de Bort.

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THURSDAY, JULY 27, 1899.

## INORGANIC CHEMISTRY.

*Lehrbuch der Anorganischen Chemie.* Von Prof. Dr. H. Erdmann. Pp. 728. (Brunswick: Vieweg und Sohn, 1898.)

THIS book is based upon the well-known work of Gorup-Besanez, the last edition of which was published in 1878, but it is practically a new book. It is printed in the style of Roscoe and Schorlemmer's treatise, handsomely illustrated, and well bound. In the 728 pages a vast amount of information is given about the facts of inorganic chemistry, and this information is in most respects well abreast of the time. The treatment and presentation of the subject are quite orthodox, except in so far as the description of experiments and of technical applications is separated from the main text, and printed in smaller type after the more general and descriptive account of a substance or group of substances has been written.

It is, perhaps, asking a good deal that a new book on inorganic chemistry should differ much except in size or price from contemporaneous works on the same subject. A perusal of the present work proceeds without any sense of freshness until the sections on helium and argon, where for the first time the personal authority of the writer is felt and approving interest excited. After this the even tenor is resumed until the second part of the work dealing with the metallic elements is reached. Here again interest is aroused, and the author may be congratulated on having produced a very readable account of what, scientifically speaking, is usually the dullest part of a book on inorganic chemistry. The accounts of technical applications which are intercalated in the text are very well written, interesting, and trustworthy.

The chief question raised by this book is how far theory is to be introduced into a book on inorganic chemistry. Is a book on inorganic chemistry to be a compendium of facts, whilst the theory is to be sought in books on general or physical chemistry? As a matter of fact, books on inorganic chemistry written up to about 1870 included a discussion of all that was known of theoretical and physical chemistry. Till then the only important quantitative laws that were clearly established referred to composition, and accordingly the theoretical part of such books dealt mainly with the laws of chemical combination and the atomic and molecular theories. But things have advanced since then; we now know a great deal about chemical dynamics, and it seems anomalous that in such a book as the one under notice there should be no general exposition of the laws governing chemical reactions and chemical equilibrium. These laws, like the laws of composition, are fundamental, and the light they throw on every-day inorganic chemistry is indispensable for a right apprehension of the facts. There seems no good reason for neglecting them in a book of 700 pages dealing with inorganic chemistry.

The theoretical part of the book is also in other respects the least satisfactory feature. It displays much of the anxious striving, to which some minds seem peculiarly liable, to be fundamental and logical on points where such exercitation is quite unnecessary and unfruitful. An advanced student surely does not need to be carefully initiated into the difference between Roman and Arabic numerals, or the meaning of $10^6$, or the impossibility of putting a quart of liquid into a pint pot; yet these and like matters are gravely and lengthily expounded. The effect is to submerge the salient points of doctrine in a sea of tedious disquisition. One cannot but wish that the space so used had been saved for the discussion of such important theoretical matters as the constitution of ozone, the hydration of salts, the absorption of hydrogen by metals, the atomic weight of tellurium—topics to which justice is not done in the book.

There are some omissions and a few mistakes in the book. The account of flame includes the apparently ineradicable dogma that the hydrogen of a hydrocarbon burns preferentially to the carbon, and that solid particles of carbon are burnt up in the mantle. The rate of the explosive wave is confused with the velocity of inflammation, and the acetylene flame, which readily melts a platinum wire, is stated to be peculiarly cool. The blemishes in the book on matters of fact are, however, not many; the information is indeed, on the whole, admirable, and we have no doubt that Prof. Erdmann's work will on this account meet the requirements of a large class of students.

A. S.

## MARINE BOILERS.

*Marine Boilers.* By L. E. Bertin; translated and edited by L. S. Robertson, with a preface by Sir William White, F.R.S. Pp. xxviii + 437. (London: John Murray, 1898.)

THIS is a translation, with some important alterations and additions, of M. Bertin's well-known work on marine boilers. M. Bertin, now Director of Naval Construction for the French Navy, was previously Principal of the *École d'application du Génie Maritime*, and his text-book was the outcome of the course of lectures on boiler construction which he delivered to the students of that institution.

The work has been translated by Mr. L. S. Robertson, an authority on the so-called water-tube boiler, and has the advantage of a graceful tribute to M. Bertin's skill as an engineer and naval architect in the form of a preface by Sir William White, Chief Constructor to the British Navy.

The book is copiously illustrated, but unfortunately the plates are sometimes by no means clear, and where dimensions are given it is often impossible to read them; as the illustrations are reproductions of those in the original French work, the dimensions are in metric units, while all the dimensions in the text have been converted into English units. Fewer illustrations, more clearly reproduced, would have been an improvement; though these remarks apply in the main to the general drawings only, the detail drawings being much clearer.

The author has divided the book into four parts, and has covered fairly completely the whole field. Part i. is devoted to the important subjects of combustion, trans-

mission of heat, corrosion, &c., and to the various methods for producing draught, with a discussion of the advantages and disadvantages of the various systems.

On p. 45 there is a slip, probably arising in conversion of units: it is stated that 5·89 lbs. of oxygen are needed to burn a pound of carbon; the figure should be 2·67 lbs. In discussing the possibility of the utilisation of the heat passing away up the funnel for warming either the feed water or the air before it passes into the furnace, there is a somewhat cur ious remark about the heat wasted in condensing the exhaust steam from an engine by cold water in the condenser, the author stating that so far "no remedy for this evil" had been proposed. Surely it has been forgotten that since the engine can only convert into work a small portion after all of the heat it receives, there must be rejection of heat in the condenser or elsewhere. In discussing the effects of corrosion in tubes, it is laid down as an axiom that only solid drawn tubes should be used, on account of the liability of the welded tube to suffer injury by corrosion along the line of weld, a remark which is sadly significant after the late disaster to a boiler in H.M.S. *Terrible*, and the finding of the Court of Inquiry.

The next two parts deal in detail with the older forms of marine boilers, the Scotch boiler mainly, and the newer tubulous or water-tube boiler. Very full descriptions are given in the second section of the more important details in a cylindrical boiler, especially in regard to the tubes and to the stays, and the section concludes with a valuable table of weights, space occupied, &c.

The third section, on water-tube boilers, is the most complete and the most interesting, as was to be expected, the tubulous boiler now reigning almost supreme in the French navy, and its use in the French mercantile marine being fairly large. Three classes of such boilers are described in three separate chapters—the limited circulation class, type Belleville; the free circulation, types Niclausse, Babcock-Wilcox, &c.; and lastly the accelerated circulation, types Normand, Thornycroft, Yarrow, &c.

In each chapter practically every boiler of the class under description which has been actually tried in practice is illustrated and briefly explained, while very full detailed descriptions are given of one or two of the important forms, such as Belleville, Niclausse, Thornycroft, &c., with much valuable information as to their performances under steam.

The last chapter in Part iii. is devoted to an able summary of the advantages and disadvantages of the tubulous type of boiler, mainly, of course, from the point of view of the marine engineer; interesting contrasting figures of comparative weights, costs, &c., per square foot of grate render this chapter one of the most useful in the book. It is surprising how cheap these apparently complex water-tube boilers are, averaging 32*l*. per square foot of grate surface.

The four chapters in Part iv. are devoted to descriptions of boiler mountings and fittings, in particular to the automatic feed arrangements, so essential to many water-tube boilers; in these chapters the illustrations are very good.

The book undoubtedly is the most complete work on the subject issued in English up to the present, and is well up to date; it should prove a valuable work of reference, not only to the marine engineer, but to the intelligent layman who takes an interest in the efficiency of our navy. The water-tube boiler, much as Mr. Allen may dislike it, has come to stay; in our navy it will gradually displace the old Scotch boiler, and we should be surprised if it does not eventually make headway in the mercantile marine.

Any one reading the book and anxious to ascertain the trend of opinion amongst English marine engineers on this important question should consult the papers read a month or two ago before the Institution of Civil Engineers by Mr. Milton and Sir John Durston.

H. B.

## OUR BOOK SHELF.

*The Elements of Euclid.* With Notes, &c., by I. Todhunter, D.Sc., F.R.S. New edition, revised and enlarged, by S. L. Loney, M.A. Pp. viii + 332, cxxxii. (London: Macmillan and Co., 1899.)

*Essentials of Plane and Solid Geometry.* By W. Wells, S.B. Pp. viii + 392. (London: Isbister and Co. Boston, D.C.: Heath and Co., 1899.)

WITHOUT altering the general character of the well-known text-book with which he has had to deal, Mr. Loney has succeeded very well in bringing it up to date. The appendix has been enlarged by the insertion of sections on poles and polars, harmonic ranges, inversion, coaxal cir cles, &c.; the number of exercises has been doubled, and, what is more important, the really valuable exercises have been starred and hints given for the solution of many of them. To teachers of the conservative school this new edition ought to prove very acceptable.

Mr. Wells' book is of quite another stamp. The author belongs to the progressive party, and makes no scruple of using hypothetical constructions or any abbreviations he finds convenient. In treating of parallels he uses Playfair's axiom, and the discussion of ratio and proportion is distinctly arithmetical. The exercises are numerous and often accompanied by figures; hints for solution are also given in many cases. Mr. Wells writes in a fresh and independent manner, and his book seems very likely to interest a student and develop any geometrical power he may have in the right way.

In another edition the author will, we trust, suppress the appendix (p. 386), which is almost entirely vitiated by an error of reasoning. Mr. Wells proposes, for instance, to prove that the circumference of a circle is less than the perimeter of any circumscribed polygon, and proceeds thus: "Of the perimeters of the circle and of its circumscribed polygons, there must be one perimeter such that all the others are of equal or greater length." He then proves that, given any circumscribed polygon, we can construct another one with less perimeter; and then infers the truth of the proposition. As a matter of fact, the statement quoted above is not justifiable; the perimeters of the polygons form a manifold, and this does not necessarily contain a least element; indeed, Mr. Wells shows that it does not. There may be a definite lower limit to the perimeter of a circumscribed polygon: even then, Mr. Wells brings forward no argument to show that this lower limit exists; still less that it is equal to the circumference of the circle. Strictly speaking, he brings the circumference of the circle into no relation of equality or inequality with any of the polygons: it just stands by itself at the end as at the beginning. It is as if one said: "We have a set of quantities $x$, 1·3, 1·33, 1·333, &c.; one of these must be at least equal to any of the rest. But this cannot be any of the decimals, because if we choose,

say, 1·3333, we can write down 1·33333, which is greater. *Therefore it must be x!*"

It is only fair to add that this unlucky paralogism seems to be a solitary blemish in an otherwise excellent book. G. B. M.

*A Manual of Surgical Treatment.* By W. Watson Cheyne, F.R.S., and F. F. Burghard, M.S., Surgeons to King's College Hospital, London. In six Parts. Part I. Pp. xiv + 285, with 66 illustrations in the text. (London and Bombay: Longmans, Green, and Co., 1899.)

SUCH a work as this has long been wanted by senior students, house-surgeons and general practitioners, who are often left in charge of capital operations performed by surgeons of repute without any precise directions as to the treatment to be adopted in cases of emergency. But the work undertakes much more than this, for it is evident that the authors will review the whole field of surgery in the light of our present pathological knowledge, showing the modern methods of treatment and explaining why they have replaced the older plans. The present part deals with the more general subjects of inflammation, gangrene, wounds, venereal disease, tuberculosis and tumours. It treats, therefore, of those parts of surgery which, perhaps more than all others, have been affected by antiseptic treatment. Mr. Watson Cheyne is so well known as one of the most distinguished pupils of Lord Lister that no better exponent of his methods could be found, and we are here presented with a clear account of the rationale of modern treatment. Thus, amongst many other more important things, we learn why poulticing is bad in the treatment of abscess, why a chronic abscess should be scraped, but an acute abscess should only have the matter let out and the loculi broken down. The facts and reasoning are excellent, but the pleasure of reading is too often marred by the form in which they are presented, as many of the sentences seem to be constructed upon a German model. The figures which illustrate the letterpress vary greatly in quality; some are excellent, others are sketchy, whilst others again are such mere outlines as to be almost unintelligible. Dr. Silk contributes an excellent article on the subject of anæsthetics, and there is a good index to this first part of the work.

*Impressions of America.* By T. C. Porter, M.A. (Oxon.), Fellow of the Chemical Society, of the Royal Astronomical Society, and of the Physical Society of London. Illustrated with diagrams and stereoscopic views. Pp. xviii + 242. (London: C. Arthur Pearson, Ltd., 1899.)

THE impressions were obtained during a pleasure trip to Niagara, the Yellowstone Park, San Francisco, the Yosemite, Utah and Colorado Springs. The author refrains from citing any of the scientific works dealing with the remarkable features of those interesting regions, but gives a graphic account of what he himself saw, and outlines a number of interesting hypotheses to account for some of the phenomena. Some of these are interesting because they show how a man of scientific habits of thought may from a hasty glance often reach conclusions very similar to those which the specialists who have studied the subject for years have demonstrated to be correct. We cannot accept Mr. Porter's ingenious hypothesis that the spiral ridges of the trunks of many trees in the Yellowstone Park are due to unequal heating by the sun and the uniform rotation of the earth, because he does not buttress it with the necessary explanation why trees in other places in the same latitude where the sun also shines unequally and the earth rotates uniformly do not also incline to a screwy form. But the little appendix on the Gulf Stream is a neat demonstration from the study of a single bottle-chart of the seasonal variation of the Gulf Stream and its attendant drift. Of course the deduction is not new; the fine charts of North Atlantic currents grouped for two-monthly intervals by the Meteorological Office bring it out perfectly, and the labours of American, British, and Scandinavian oceanographers, and of the Prince of Monaco, have done much to find the reasons for the observed variations. We might venture, however, to remind Mr. Porter that the course of the Gulf Stream shown on a single small scale map is as conventional and empirical a representation of oceanic circulation as the isotherms on a map of mean annual temperature are of the climates of the world. The generalisation in no way implies that the seasonal changes are unknown.

A new theory of geysers to fit the phenomena of the Yellowstone Park is also printed in the appendix in the form of a paper read to the Physical Society. It points out defects in Tyndall's well-known theory, and introduces a syphon-bend in the underground channel and the spheroidal state induced by the intense heat of the rocks as more probable explanations.

The great merit and the unique character of the book depend, however, not on the author's impressions or his theories, but on the incomparable series of photographs which he took. These are reproduced in the form of stereoscopic views, and a neat little lenticular stereoscope is supplied with the volume. The views shown in these illustrations are admirably selected and splendidly photographed. They are reproduced by the half-tone process as separate plates, and very well printed. As a diary of the observations of a man of science at leisure there is much of interest in the whole book, which has also the advantage of being brief. H. R. M.

*Tables for Quantitative Metallurgical Analysis for Laboratory Use.* By J. James Morgan, F.C.S., Member Soc. Chem. Industry, Member Cleveland Inst. Engineers. Tables xvi. (London: Charles Griffin and Co., Ltd., 1899.)

TABLES for qualitative analysis are to be found in every chemical laboratory, and are used by every analyst at one time or another. Any attempt to supply chemists with information on quantitative analysis drawn up in the same convenient form must therefore be welcome. The present collection of tables has been carefully prepared, and is well arranged. It includes the analyses of iron ores, steel, limestone, boiler incrustation, certain slags, gaseous fuels, water, coal, and a few of the common metals and alloys. Alternative methods are not given, but the tables will be found very useful in saving the time of an analyst engaged in the examination of materials with which he is not accustomed to deal in the ordinary course of his daily work.

## LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### Tides of the Gulf and River St. Lawrence and Bay of Fundy.

PERMIT me to invite your attention to the latest report of the engineer in charge of the survey of the tides and currents of the coast waters of Canada, Mr. W. Bell Dawson, a copy of which has been addressed to you.

This survey, commenced by the Government of Canada in 1894, is of great importance, not merely in the interest of hydrographical science, but of the large and increasing trade which finds its way along the gulf and river St. Lawrence, the greatest water-way from the North Atlantic into the northern part of the American continent, and which, like all

similar tide-ways, is affected by the complex action of the tides and consequent currents.

It is much to be regretted that the economy or parsimony of the Government has caused a suspension for the present of the special survey of the currents, and has restricted the work to tidal observations, which, though of great value to the shipping interests, can only be considered as preliminary in regard to the investigation of the currents themselves, which lead to so many losses of property and life, and tend to high rates of insurance, injurious to the shipowners and merchants of Canada, and through them to those of an empire as a whole.

The present report, in addition to what can be done with the insufficient grant allowed, in the matter of tide-gauges and tide-tables, has reference to the behaviour of the gigantic tides of the Bay of Fundy, when confined by the converging coasts at the head of the bay, and their relation to the smaller tides on the opposite side of the isthmus connecting Nova Scotia and New Brunswick at Bay Verte on the Gulf of St. Lawrence. These and the phenomena of the "bore" at the head of the Bay of Fundy are here for the first time described, illustrated by maps and sections, and tabulated, and will be found of the greatest interest by all who desire information as to the exceptional tides of this region.

J. W. DAWSON.

### School Laboratory Plans.

As one who has had the privilege of seeing Mr. Dymond's excellent arrangement and outlay of money in his laboratory at Chelmsford, may I make a comment on his letter in your issue of July 13? I think the conditions of work in an average school laboratory show some points of difference from those in Mr. Dymond's laboratory. Of course qualitative analysis is now confined to quite senior boys, who can be persuaded not to treat the subject as if they were working from a cookery book; but though owning no allegiance to the Science and Art Department, I believe that drawers and lockers are valuable, not only in relieving the general stock of the laboratory (very heavy for descriptive and quantitative work) of some smaller apparatus in constant use, but also in conferring a feeling of ownership, which induces some care and respect in a boy for his belongings. With snap-locks answering to one master key, and the lockers of each class bearing a label of a distinctive colour, they may be at once opened by the assistant before a class, so that there need be no keys to lose and no depredations on neighbouring lockers. Mr. Dymond's objection to that most durable of woods—teak—or why it alone should be left in a dirty state, I do not understand. Admitting that in all but very elementary work some tuition in the way of lectures is necessary, a laboratory will generally possess a lecture room; and where this is a separate room, I grudge the space usually given to a demonstrator's table in the laboratory, because no large section of a practical class is ever doing the same experiment at the same time. Physics, again, is often involved in this question of arrangement in a school, since the two subjects may, I think, with little detriment and great economy often have a common lecture room. Considering the prodigal waste of space often seen in laboratories, and the number now being built by public bodies, some further views on this subject ought to be of value.

A. E. MUNBY.

Felsted School.

### Duties of Provincial Professors.

THE article in your issue of July 13 upon "The Duties of Provincial Professors" will be welcomed by all professors in local university colleges. It insists none too strongly upon the disadvantageous position they occupy with regard to the opportunity for the prosecution of original research, and the unfortunate result of compelling our best students to complete their scientific education in Germany.

It is not sufficiently recognised that the reputation of a university is advanced more by the contributions to science and literature produced by its staff than by the mere number of its students. Unfortunately, the staff of assistants in the university colleges is often totally inadequate to the work required, and the knowledge that their energies will be dissipated in elementary teaching, and no time given for continuing original investigation, is deterring men of really high academic distinction from accepting such appointments. The government of a local college is largely directed by business men, and the methods which ensure commercial success are hardly those best calculated to further the interests of true education. Salvation lies apparently in the fact of Government inspection; the Government grant is only given when the education is of an advanced university type; and, judging from the tenor of the Treasury Minute, "University Colleges, Great Britain—Grant in Aid," the fullest recognition is given to those colleges which offer opportunities for advanced work and research and can show an adequate educational equipment.

"A PROFESSOR."

July 23.

IN the articles on "The Duties of Provincial Professors," it is stated: "In such cases students . . . may be called on to give evidence against their professors." This is almost incredible, but, to my great astonishment, I learnt quite lately that the only possible alteration in the statement consistent with truth would be the substitution of the words "have been" for "may be." The adoption of such a course must be fatal to good discipline in a college, and it leaves the members of the staff at the mercy of a few unruly and ignorant students whose disposition to learn may be small, though their capacity for agitation is great. From time to time students of this description will be found in every college. Apart altogether from these evils, there is another reason why the practice of allowing students to give evidence against a professor is decidedly objectionable; and that is, the lay members of the governing body of a provincial college are not likely to fully understand how incompetent the average pass student is to form an opinion as to the soundness of the teaching he receives.

In the interests, not merely of the provincial colleges, but of higher education throughout the country, it is desirable that professors should not, for any except very grave reasons, and then only after a perfectly fair trial, be forced to resign their offices.

P.

## *THE REDE LECTURE.*[1]

### THE WAVE THEORY OF LIGHT: ITS INFLUENCE ON MODERN PHYSICS.

OUR era is distinguished from preceding ages by wonderful utilisation of natural forces; man, that weak and defenceless being, has been enabled by his genius to acquire an extraordinary power, and to bend to his use those subtle yet dreadful agents whose very existence was unknown to our ancestors. This marvellous increase of his material power in modern times is due only to the patient and profound study of natural phenomena, to the exact knowledge of the laws that governed them, and to the skilful combining of their effects. But what is peculiarly instructive is the disproportion between the primitive phenomenon and the greatness of the effects which industry has drawn from it. Thus, those formidable engines, based on electricity or steam, grew neither from lightning nor the volcano; they had their birth from scarcely perceptible phenomena which would have remained for ever hidden from the vulgar eye, but that penetrating observers were able to recognise and appreciate. This humble origin of most of the great discoveries which are to-day a benefit to the

[1] Besides the interest presented by a glance on the progress and the influence of optical science, this lecture offers the conclusions of a careful study on Newton's treatise of optics. It will be seen that the thought of the great physicist has been singularly altered by a sort of legendary interpretation developed in the elementary treatises where the emission-theory is expounded. In order to make the theory of fits clearer, the commentators have imagined to materialise the luminous molecule under the form of a rotating arrow offering now its head, now its side. This mode of exposition has contributed to lead to the belief that the whole emission-theory was comprehended in this rather childish image.

Nowhere in his treatise does Newton give a mechanical illustration of the luminous molecule: he confines himself to the description of facts, and sums them up in an empirical statement without any hypothetical explanation. Moreover, he denies the opinion that he raises any theory, though he holds occasionally as very probable the intervention of the waves excited in the ether.

So that the general impression resulting from the reading of the treatise and above all of the "queries" in the 3rd Book, is the following: Newton, far from being the adversary of the Cartesian system, as he is commonly represented, looks, on the contrary, very favourably at the principles of this system. Struck by the resources which the undulatory hypothesis would offer for the explanation of the luminous phenomena, he would have adopted it, if the grave objection concerning the rectilinear propagation of light (only recently solved by Fresnel) had not prevented him.

whole human race, shows us plainly that the scientific spirit is at present the mainspring of the life of nations, and that it is in the onward march of pure science that we are to look for the secret of the growing power of the modern world. Whence a series of questions which demand more and more the attentions of all. How did this taste towards the study of natural philosophy, so dear to the ancient philosophers, abandoned for centuries, again revive and grow? What are the phases of its advance? How appeared the new notions which have so deeply modified our ideas on the mechanism of nature's forces? What paths, rich in discoveries, lead us gradually unawares to those admirable generalisations in accordance with the vast plan foreseen by the founders of modern physics? These are the questions which as a physicist I intend to inquire into before you. The subject is rather abstract, I might say severe. But no other has seemed more worthy of your attention during the *fête* which the University of Cambridge celebrates to-day in honour of the Lucasian Professorship Jubilee of Sir Geo. Gabriel Stokes, who in his fine career has laid a master-hand on the very problems which seemed to me the most conducive to the progress of natural philosophy. The subject is all the more fitted here, as in citing the names of those great minds to whom modern science is most indebted, we found amongst those who most honoured the University of Cambridge—its Professors and Fellows—Sir Isaac Newton, Thomas Young, George Green, Sir George Airy, Lord Kelvin, Clerk Maxwell, Lord Rayleigh, and the memory of that glory which links to-day back through the centuries would add lustre to the present ceremony.

Let us then, in a rapid glance of the scientific revival, point out the secret but mighty influence which has been the directing force of modern physics. I am inclined to attribute to the study of light, and to the attraction it has for the highest minds, one of the most effective causes of the return of ideas towards natural philosophy, and consider optics as having exercised on the advance of science an influence it would be difficult to exaggerate. This influence, already clear at the dawn of the experimental philosophy under Galileo, grew so rapidly that to-day it is easy to foresee a vast synthesis of natural forces founded on the principles of the wave theory of light. This influence is easy to understand if we reflect that light is the way by which knowledge of the exterior world reaches our intelligence. It is, in fact, to sight that we owe the quickest and most perfect notions of the objects around us: our other senses, hearing, feeling, also bring their share of learning, but sight alone affords us abundant means of simultaneous information such as no other sense can. It is, therefore, not surprising that light, this lasting link between us and the outward world, should intervene with the varied sources of its inner constitution to render more precise the observation of natural phenomena. Thus each discovery concerning new properties of light has had an immediate effect on the other branches of human knowledge, and has indeed determined the birth of new sciences by affording new means of investigation of unexpected power and delicacy.

Optics are really a modern science. The ancient philosophers had no idea of the complexity of what is vulgarly called light; they confounded in the same name what is proper to man, and what is exterior. They had, however, perceived one of the characteristic properties of the link, which exists between the source of light and the eye, which receives the impression, "Light moves in a straight line." Common experience had revealed this axiom through the observation of the shining trains that the sun throws across the skies, piercing misty clouds, or penetrating into some dark space. Hence arises two empirical notions—the definition of the ray of light, and that of the straight line. The one became the basis of optics, the other that of geometry.

Very little remains to us of the ancient books upon optics. Yet we are aware that they knew the reflection of the luminous rays on polished surfaces, and the geometrical explanation of the images formed by mirrors.

We must wait many centuries until the scientific revival for a new progress in optics (but then a very considerable one) opens the new era; it is the invention of the telescope.

The new era begins with Galileo, Boyle and Descartes, the founders of experimental philosophy. All devote their life to meditations on light, colours, and forces. Galileo lays the base of mechanics and with the refracting telescope that of astro-physics. Boyle improves experimentation. As to Descartes, he embraces with his penetrating mind the whole of natural philosophy; he throws away the occult causes admitted by the scholastics, and proclaims as a principle that all phenomena are governed by the laws of mechanics. In his system of the universe, light plays a prominent part [1]: it is produced by the waves excited in the subtle matter which, according to his view, pervades space. This subtle matter (which represents what we call to-day the ether) is considered by him as formed of particles in immediate contact; it constitutes thus at the same time the vehicle of the forces existing between the material bodies which are plunged in it. We recognise the famous "vortices of Descartes," sometimes admired, sometimes baffled during the last centuries, but to which skilful contemporaneous physicists have rendered the importance they deserve.

Whatever may be the opinions granted to the exactness of the deductions of this great philosopher, we must be struck by the boldness with which he proclaims the connection of the great cosmical problems, and foretells the solutions which actual generations did not yet entirely accept but drew insensibly to.

In Descartes' view the mechanism of light and that of gravitation are inseparable; the seat of corresponding phenomena is this subtle matter which pervades the universe, and their propagation is performed by waves around the acting centres.

This conception of the nature of light shocked the opinions in vogue; it raised strong opposition. Since the oldest times it was the habit to imagine the luminous ray as the trajectory of rapid projectiles thrown by the radiant source. Their shock on the nerves of the eye produce vision; their resistance or changes of speed, reflection or refraction. The Cartesian theory had, however, some seductive aspects which brought defenders. The waves excited on the surface of still water offer so clear an image of a propagated motion around a disturbing centre! On the other hand, do not the sonorous impressions reach our ear by waves? Our mind feels yet a real satisfaction in thinking that our most sharp and delicate organs are both impressed by a mechanism of the same nature.

Yet a serious difference arose. Sound does not necessarily travel in straight lines as light does. It travels round any object opposed to it, and will follow the most circuitous routes with scarcely any loss of strength. Physicists were thus divided into two camps. In one the partisans of emission, in the other those of the wave theory, each system boasting itself superior, and indeed each being so in certain respects. Other phenomena had to be examined in order to decide between them.

The chance of discovery brought to view several phenomena which ought to have decided in favour of wave theory, as was proved a century later; but the simplest truth does not prevail without long endeavour.

A strange compromise was effected between the two systems, helped on by a name great among the greatest, and for a century the theory of emission triumphed.

The tale is a strange one. In 1661 a young scholar,

[1] *Le Monde de M. Descartes, ou le Traité de la Lumière* (Paris, 1664).

full of eagerness and penetration, enters Trinity College, Cambridge; his name is Isaac Newton. He has already in his village read Kepler's "Optics." Almost immediately, and while following Barrow's lectures upon optics, he studies the geometry of Descartes with passionate care; with his savings he buys a prism that he might examine the properties of colour and meditate deeply on the causes of gravitation. Eight years later his masters think him worthy to succeed Barrow in the Lucasian Professorship, and in his turn he also teaches optics. The pupil soon becomes greater than his teacher, and he gives out this great result: White light which seemed the type of pure light is not homogeneous; it consists of rays of different refrangibility, and he demonstrates it by the celebrated experiment of the solar spectrum, in which a ray of white light is decomposed into a series of coloured rays like a rainbow; each shade of the colour is simple, for the prism does not decompose the shade. This is the origin of the spectral analysis. This analysis of white light brought Newton to explain the colours of the thin plates which are, for instance, observed in soap-bubbles. The fundamental experiment, that of Newton's rings, is one of the most instructive in optics, while the laws that govern it are of admirable simplicity.

The theory was expounded in a discourse addressed to the Royal Society with the title, "A New Hypothesis concerning Light and Colour."

This discourse called forth from Hooke a sharp complaint. Hooke also had already examined the colour of thin plates, and endeavoured to explain them in the wave system. He had the merit, which Newton himself readily granted, to substitute for the progressive wave of Descartes a vibrating one—a new and extremely important notion. He had even noticed the part of the two reflecting surfaces of the thin plate, and the mutual action of the reflected waves. Consequently Hooke should have been the very forerunner of the modern theory if he had had, as Newton, the clear intelligence of the simple rays. But his vague reasoning to explain the colours takes away all demonstrative value from his theory.

Newton is very affected by this complaint of priority, and combats the arguments of his adversary by remarking that the wave theory is inadmissible because it does not explain the existence of the luminous ray and of the shadows. He denies the opinion that he has raised a theory; he certifies that he does not admit either the wave hypothesis or the emission, but he says "He shall sometimes, to avoid circumlocution and to represent it conveniently, speak of it as if he assumed it and propounded it to be believed." And, really, in the Proposition XII. (second book of his Optics),[1] which constitutes what was since called the theory of fits, Newton remains absolutely on the ground of facts. He says simply, the phenomena of thin plates prove that the luminous ray is put alternatively in a certain state or fit of easy reflexion and of easy transmission. He adds, however, that if an explanation of these alternative states is required they can be attributed to the vibrations excited by the shock of the corpuscles, and propagated under the form of a wave in ether.[2]

After all, notwithstanding his desire to remain on the firm ground of facts, Newton cannot help trying a rational explanation. He has too carefully read the writings of Descartes not to be heartily, as Huygens, a partisan of the universal mechanism and not to wish secretly to find in the pure undulations the explanation of the beautiful phenomena he has reduced to such simple laws. But his third book on optics more especially proves his Cartesian aspirations, and, above all, his perplexity. His famous "Queries" expose so forcibly his argument in favour of the wave theory of light that Thos. Young will later cite them as proof of the final conversion of Newton to the wave theory. Newton would certainly have yielded to this secret inclination had the inflexible logic of his mind allowed him to do so; but when after enumerating the arguments the wave theory of light offers in explanation of the intimate nature of light, when he arrived at the last "queries" he stops, as if seized by a sudden remorse, and throws it away. And the sole argument is that he does not see the possibility of explaining the rectilinear transmission of light.[1] Viewed from this standpoint the third book of *Optiks* is no longer only an

[1] Prop. XII.—Every Ray of Light in its passage through any refracting Surface is put into a certain transient constitution or state, which in the progress of the Ray returns at equal Intervals, and disposes the Ray at every return to be easily transmitted through the next refracting Surface, and between the returns to be easily reflected by it. (Sir Isaac Newton, "*Opticks*: or a *Treatise* of the Reflections, Refractions, Inflexions and Colours of *Light*." London, 1718. Second edition, with additions. P. 293.

[2] *Loc. cit.*, p. 299.

[1] First, here is an extract from the "Queries" which prove the leaning of Newton's views towards the undulatory theory and the Cartesian ideas.

"Query 12.—Do not the Rays of light in falling upon the bottom of the eye excite Vibrations in the *Tunica Retina*? Which Vibrations, being propagated along the Solid Fibres of the optick nerves into the brain, cause the Sense of seeing. . ."

"Query 13.—Do not several sorts of Rays make Vibrations of several bignesses, which, according to their bignesses, excite sensations of several colours, much after the manner that the vibrations of the air, according to their several bignesses, excite sensation of several sounds? And particularly do not the most refrangible rays excite the shortest vibrations for making a sensation of deep violet, the least refrangible the largest for making a sensation of deep red, &c.? . . ."

"Query 18.— . . . Is not the heat of the warm room convey'd through *the vacuum* by the vibrations of a much subtiler medium than air, which, after the air was drawn out remained in the *vacuum*? [ether] and is not this medium the same with that medium by which light is refracted and reflected, and by whose vibrations light communicates heat to bodies, and is put into fits of easy reflection and easy transmission? . . . And is not this medium exceedingly more rare and subtile than the air, and exceedingly more elastic and active? and doth it not readily pervade all bodies? and is it not (by its elastick force) expanded through all the heavens?"

Newton, afterwards, considers the possible connection of this medium (ether) with the gravitation and the transmission of the sensations and motion in living creatures (queries 19 to 24).

The dissymetrical properties of the two rays propagated in the Iceland spar, draw equally his attention (query 25 to 26).

Here appears this sudden and unexpected going back, this sort of remorse from having too kindly expounded the resources of the Cartesian theory, based on the *plenum*; he makes an apology as follows:

"Query 27.—Are not all hypotheses erroneous which have hitherto been invented for explaining the phenomena of light, by new modifications of the rays? . . ."

"Query 28.—Are not all hypotheses erroneous in which light is supposed to consist in pression or motion, propagated through a fluid medium? . . . and if it (light) consisted in pression or motion, propagated either in an instant or in time, it would bend into shadow. For pression or motion cannot be propagated in a fluid in right lines beyond an obstacle, which stops part of the motion, but will bend and spread every way into the quiescent medium which lies beyond the obstacle. . . . For a bell or a canon may be heard beyond a hill which intercept the light of sounding body, and sounds are propagated as readily through crooked pipes as through straight ones. But light is never known to follow crooked passages nor to bend into the shadow. . . ."

Stopping before this objection Newton is forced to come back to the corpuscular theory.

"Query 29.—Are not the rays of light very small bodies emitted from shining substances? . . ."

"Query 30.—Are not gross bodies and light convertible into one another . . . ? The changing of bodies into light and light into bodies, is very conformable to the course of nature, which seems delighted with transmutations. . . ."

Logic urges him to go on with the old hypothesis of the *vacuum* and *atoms*, and even to invoke the authority of the Greek and Phœnician philosophers in this matter (query 28, p. 343), therefore it is not surprising to see his perplexity expressed by the following words:—

"Query 31, and the last.—Have not the small particles of bodies certain powers, virtues, or forces, by which they act at a distance not only upon the rays of light for reflecting, refracting and inflecting them, but also upon one another for producing a great part of the phenomena of nature? . . ."

But he perceives that he is going rather far, and compromising himself, therefore his secret tendency, developed in the foremost queries, reappear a little while:—

". . . How these attractions may be performed I do not here consider. What I call attraction may be perform'd by impulse, or by some other means unknown to me . . ."

Many other curious remarks could be made on the state of mind of the great physicist, geometer and philosopher, which is artlessly revealed in those "queries." The preceding short extracts are sufficient, I believe, to justify the conclusion which I get from the study of the 3rd Book, namely, that Newton had not at all on the mechanism of light the definite ideas which have been attributed to him as founder of the emission-theory. Really, he is hesitating between the two opposite systems, perceiving clearly their insufficiency; and in this discussion he is endeavouring to go away as little as possible from the facts. That is the reason for which he has stated no dogmatic theory. It would be, therefore, unjust to make Newton responsible for every consequence which the emission partisans have sheltered under his authority.

impartial discussion of opposite systems; it appears as the painting of the suffering of a mighty genius, worried by doubt, now led away by the seductive suggestions of his imagination, now recalled by the imperious requirements of logic. It is a drama: the everlasting struggle between love and duty; and duty won.

Such, I take it, is the inner genesis of the theory of fits—a strange mingling of two opposite systems. It was much admired, presented, as it was, by the great mathematician, who had the glory of submitting the motions of all celestial bodies to the one law of universal gravitation.

To-day this theory is abandoned; it is condemned by the *experimentum crucis* of Arago, realised by Fizeau and Foucault. One ought, however, to acknowledge that it has constituted a real progress by the precise and new notions which it contains. The ray of light, considered up till then, was simply the trajectory of a particle in rectilinear motion; the ray of light, such as Newton described it, possesses a regular periodic structure, and the period or interval of fits, characterises the colour of the ray. This is an important result. It only requires a more suitable interpretation to transform the luminous ray into a vibratory wave; but we had to wait a century, and Dr. Thomas Young, in 1801, had the honour of discovering it.

Resuming the study of thin plates, Thomas Young shows that everything is explained with extreme simplicity, if it be supposed that the homogeneous luminous ray is analogous to the sonorous wave produced by a musical sound; that the vibrations of ether ought to compose—that is to say, to interfere—according to the expression that he proposes as to their mutual actions.

Although Young had taken the clever precaution of supporting his views by the authority of Newton,[1] the hypothesis found no favour; his principle of interference led to this singular result that light added to light could, in certain cases, produce darkness, a paradoxical result contradicted by daily experience. The only verification that Young brought forward was the existence of dark rings in Newton's experiment, darkness due, according to him, to the interference of waves reflected on the two faces of the plate. But as the Newtonian theory interpreted the fact in a different manner, the proof remained doubtful; an *experimentum crucis* was wanting. Young did not have the good success to obtain it.

The theory of waves relapsed then once more into the obscurity of controversy, and the terrible argument of the rectilinear propagation was raised afresh against it. The most skilled geometers of the period—Laplace, Biot, Poisson—naturally leaned to the Newtonian opinion; Laplace in particular, the celebrated author of the "Mecanique Celeste," had even taken the offensive. He was going to attack the theory of waves in its most strongly fortified entrenchments, which had been raised by the illustrious Huygens.

Huygens, indeed, in his "Traité de la Lumière," had resolved a problem before which the theory of emission had remained mute; that is to say, the explanation of the double refraction of Iceland spar: the wave theory (on the contrary) reduced to the simplest geometrical construction the path of the two rays, ordinary and extraordinary; experiment confirmed the results in every point. Laplace succeeded in his turn (with the help of hypotheses of the constitution of luminous particles) to explain the path of these strange rays. The victory of the theory of particles then appeared complete; a new phenomenon arrived also appropriately to render it striking.

Malus discovered that a common ray of light reflected under a certain angle acquired unsymmetrical properties similar to those rays from a crystal of Iceland spar. He explained this phenomenon by an orientation of the luminous molecule, and, consequently, named this light *polarised light*. This was a new success for emission.

The triumph was not of long duration. In 1816 a young engineer, scarcely out of the École Polytechnique, Augustin Fresnel, confided to Arago his doubts on the theory then in favour, and pointed out to him the experiments which tended to overthrow it.

Supporting himself on the ideas of Huygens, he attacked the formidable question of rays and shadows, and had resolved it: all the phenomena of diffraction were reduced to an analytical problem, and observations verified calculation marvellously. He had, without knowing it, rediscovered Young's reasonings as well as the principle of interference; but more fortunate than he, he brought the *experimentum crucis*—the two-mirror experiment; there, two rays, issuing from the same source, free from any disturbance, produced when they met, sometimes light, sometimes darkness. The illustrious Young was the first to applaud the success of his young rival, and showed him a kindness which never changed.

Thus, thanks to the use of two-mirror experiment, the theory of Dr. Young (that is to say, the complete analogy of the luminous ray and the sound wave) is firmly established.

Moreover, Fresnel's theory of diffraction shows the cause of their dissimilarity; light is propagated in straight lines because the luminous waves are extremely small. On the contrary, sound is diffused because the lengths of the sonorous waves are relatively very great.

Thus vanished the terrible objection which had so much tormented the mind of great Newton.

But there remained still to explain another essential difference between the luminous wave and the sonorous wave; the latter undergoes no polarisation. Why is the luminous wave polarised?

The answer to this question appeared so difficult that Young declared he would renounce seeking it. Fresnel worked more than five years to discover it; the answer is as simple as unexpected. The sound wave cannot be polarised because the vibrations are longitudinal; light, on the other hand, can be polarised because the vibrations are transverse, that is to say, perpendicular to the luminous ray.

Henceforth the nature of light is completely established, all the phenomena presented as objections to the undulatory theory are explained with marvellous facility, even down to the smallest details.

I would fain have traced by what an admirable suite of experiment and reasoning Fresnel arrived at this discovery, one of the most important of modern science: but time presses.

It has sufficed me to explain how very great the difficulties were which he had to overcome in order to establish it.

I hasten to point out its consequences.

You saw, at starting, the purely physiological reasons which make the study of light the necessary centre of information gathered by human intelligence. You judge now, by the march of this long development of optical theories, what preoccupations it has always caused to powerful minds interested in natural forces. Indeed, all the phenomena which pass before our eyes involve a transmission to a distance of force or movement; let the distance be infinitely great, as in celestial space, or infinitely small, as in molecular intervals, the mystery is the same. But light is the agent which brings us the movement of luminous bodies; to fathom the mechanism of this transmission is to fathom that of all others, and Descartes had the admirable intuition of this when he comprehended all these problems in a single mechanical conception: here is the secret bond which has always attracted the physicists and geometers towards the study

[1] The Bakerian Lecture, "On the Theory of Light and Colours." By Thomas Young. *Phil. Trans.* of the R.S. for the year 1802.

of light. Looked at from this point of view, the history of optics acquires a considerable philosophical importance; it becomes the history of the successive progress of our knowledge on the means that nature employs to transmit movement and force to a distance.

The first idea which came to the mind of man (in the savage state) to exercise his force beyond his reach is the throwing of a stone, of an arrow or of some projectile; this is the germ of the theory of emission. This theory corresponds to a philosophical system which assumes an empty space in which the projectile moves freely. At a more advanced degree of culture, man having become a physicist, has had the more delicate idea of the transmission of movement by waves, suggested at first by the study of waves, afterwards by that of sound.

This second way supposes, on the other hand, that space is a plenum; there is no longer here transport of matter; particles oscillate in the direction of propagation, and it is by compression or rarefaction of a continuous elastic medium that movement and force are transmitted. Such has been the origin of the theory of luminous waves; under this form it could only represent a part of the phenomena; it was therefore insufficient.

But geometers and physicists before Fresnel did not know of any other undulatory mechanism in a continuous medium.

The great discovery of Fresnel has been to reveal a third mode of transmission quite as natural as the preceding one, but which offers an incomparable richness of resources. These are the waves of transverse vibrations excited in an incompressible continuous medium, those which explain all the properties of light.

In this undulatory mode the displacement of particles brings into play an elasticity of a special kind; this is the relative slipping of strata concentric to the disturbance which transmits the movement and the effort. The character of these waves is to impose on the medium no variation of density as in the system of Descartes. The richness of resource mentioned above depends upon the fact that the form of the transverse vibration remains indeterminate, and thus confers on waves an infinite variety of different properties.

The rectilinear, circular and elliptical forms characterise precisely the polarisations, so unexpected, which Fresnel discovered, and by the aid of which he has so admirably explained the beautiful phenomena of Arago produced by crystallised plates.

The possible existence of waves which are propagated without change of density, has profoundly modified the mathematical theory of elasticity. Geometers found again in their equations, waves having transverse vibrations which were unknown to them; they learnt besides, from Fresnel, the most general constitution of elastic media, of which they had not dreamt.

It is in his admirable memoir on double refraction that this great physicist set forth the idea that in crystals the elasticity of the ether ought to vary with the direction, an unexpected condition and one of extreme importance, which has transformed the fundamental bases of molecular mechanics; the works of Cauchy and Green are the striking proofs of it. From this principle Fresnel concluded the most general form of the surface of the luminous wave in crystals, and found (as a particular case) the sphere and ellipsoid that Huygens had assigned to the Iceland spar crystal. This new discovery excited universal admiration among physicists and geometers; when Arago came to expound it before the Académie des Sciences, Laplace, who had been such a long time hostile, declared himself convinced. Two years later Fresnel, unanimously elected a member of the Academy, was elected with the same unanimity foreign member of the Royal Society of London; Young himself transmitted to him the announcement of this distinction, with personal testimony of his sincere admiration.

The definite foundation of the undulatory theory imposes the necessity of admitting the existence of an elastic medium to transmit the luminous movement. But does not all transmission to a distance of movement or of force imply the same condition? To Faraday is due the honour of having, like a true disciple of Descartes and Leibnitz, proclaimed this principle, and of having resolutely attributed to reactions of surrounding media the apparent action at a distance of electrical and magnetic systems. Faraday was recompensed for his boldness by the discovery of induction.

And since induction acts even across a space void of ponderable matter, one is forced to admit that the active medium is precisely that which transmits the luminous waves, the ether.

The transmission of a movement by an elastic medium cannot be instantaneous; if it is truly luminous ether that is the transmitting medium, ought not the induction to be propagated with the velocity of luminous waves?

The verification was difficult. Von Helmholtz, who tried the direct measurement of this velocity, found, as Galileo formerly, for the velocity of light a value practically infinite.

But the attention of physicists was attracted by a singular numerical coincidence. The relation between the unity of electrostatic quantity to the electro-magnetic unit is represented by a number precisely equal to the velocity of light.

The illustrious Clerk Maxwell, following the ideas of Faraday, did not hesitate to see in the relationship the indirect measure of the velocity of induction, and by a series of remarkable deductions he built up this celebrated electro-magnetic theory of light, which identifies in one mechanism three groups of phenomena completely distinct in appearance, light, electricity, and magnetism.

But the abstract theories of natural phenomena are nothing without the control of experiment.

The theory of Maxwell was submitted to proof, and the success surpassed all expectation. The results are too recent and too well known, especially here, for it to be necessary to insist upon them.

A young German physicist, Henry Herz, prematurely lost to science, starting from the beautiful analysis of oscillatory discharges of Von Helmholtz and Lord Kelvin, so perfectly produced electric and electro-magnetic waves, that these waves possess all the properties of luminous waves; the only distinguishing peculiarity is that their vibrations are less rapid than those of light.

It follows that one can reproduce with electric discharges the most delicate experiments of modern optics —reflection, refraction, diffraction, rectilinear, circular, elliptic polarisation, &c. But I must stop, gentlemen. I feel that I have assumed too weighty a task in endeavouring to enumerate the whole wealth which waves of transverse vibrations have to-day placed in our hands.

I said at the beginning that optics appeared to me to be the directing science in modern physics.

If any doubt can have arisen in your minds, I trust this impression has been effaced to give place to a sentiment of surprise and admiration in seeing all that the study of light has brought of new ideas on the mechanism of the forces of nature.

It has insensibly restored the Cartesian conception of a single medium refilling space, the seat of electrical, magnetic and luminous phenomena; it allows us to foresee that this medium is the depositary of the energy spread throughout the material world, the necessary vehicle of every force, the origin even of universal gravitation.

Such is the work accomplished by optics: it is perhaps the greatest thing of the century!

The study of the properties of waves, viewed in every aspect, is therefore, at the present moment, the most fertile study.

It is that which has been followed in the double capacity of geometer and physicist by Sir George Stokes, to whom we are about to pay so touching and deserved a homage. All his beautiful researches, both in hydrodynamics as well as in theoretical and practical optics, relate precisely to those transformations which various media impose on waves which traverse them.

In the many phenomena which he has discovered or analysed, movements of fluids, diffraction, interference, fluorescence, Röntgen rays, the dominant idea which I pointed out to you is always visible; it is that which makes the harmonious unity of the scientific life of Sir George Stokes.

The University of Cambridge may be proud of the Lucasian Chair of Mathematical Physics, because from Sir Isaac Newton up to Sir George Stokes it has contributed a glorious part towards the progress of Natural Philosophy! A. CORNU.

## NOTES.

WE are glad to be able to publish this week a translation of the Rede Lecture delivered at Cambridge by Prof. Alfred Cornu, professor of experimental physics in the École polytechnique, Paris, and a Foreign Member of the Royal Society, on the occasion of the recent celebration of the jubilee of Sir George Stokes as Lucasian professor of mathematical physics. Prof. Cornu delivered the lecture in French, and we are indebted to him for the translation of his brilliant discourse, which immediately precedes this Note.

AN interesting gathering took place at the Star and Garter Hotel, Richmond, on Thursday last, when a number of friends joined with the members of the Physiological Society in giving a congratulatory dinner to Sir John Burdon-Sanderson, Bart., F.R.S., and Prof. Michael Foster, K.C.B., Sec.R.S., in honour of Her Majesty's recent recognition of the great services they have rendered to science. The chair was taken by Prof. Schäfer, F.R.S., and the friends who assembled to support him in doing honour to the distinguished guests numbered considerably over a hundred. The principal speeches of the evening were made by the chairman, by Sir John Burdon-Sanderson, and by Prof. Michael Foster, all of whom were able to give interesting reminiscences of the early days of physiology in England, and of the great difficulties which used to be thrown in the way of those who wished to study the subject. Owing to the exigencies of the various examinations now in progress, many physiologists were unable to be present in the earlier part of the evening, but the great interest taken in the proceedings was shown by the long journeys undertaken by several in order that they might take part at the dinner.

THE special number of the *Atti*, containing the report of the anniversary meeting of the Reale Accademia dei Lincei, announces the annual awards of prizes. The Royal prize for astronomy for 1896 remains unawarded. The Royal prize for philology and languages is divided equally between Prof. Pio Rajna, for his critical edition of Dante's "De Vulgari Eloquentia," and Prof. Claudio Giacomino, for his studies on the Basque language. The prize for history and geography is unawarded, and the same is true of a prize offered for 1898 for perfecting the theory of motion of a rigid body. The Ministerial prize of 3400 lire for history for 1898 is divided, a prize of 1700 lire being awarded to Prof. Gaetano Salvemini, and smaller awards being made to Profs. Alberto Pirro, Niccolò Rodolico, and Michele Rosi. Of the Ministerial prize of 3400 lire for mathematics for 1898, a prize of 2000 lire is awarded to Prof. Ettore Bortolotti, and awards of 700 lire each are made to Profs. Federico Amodeo and Francesco Palatini. The adjudicators state that the works of Prof. Pirondini would have gained an award had not some of them received recognition on a previous occasion. The adjudicators of the Ministerial prize for philosophical and social sciences for 1897 award 500 lire each to Profs. Albino Nagy, Luigi Ambrosi, and Tarozzi. The Mantellini prize is unawarded. Of the Santoro prize for electro-technics one half is awarded to Signor R. Arnò, for his share in the joint invention with the late Prof. G. Ferraris of a new transformer. The Santoro prize for chemistry as applied to agriculture is unawarded, and from the Carpi prize for mathematical physics for 1897-8 a sum of 500 lire is awarded to Signor C. Canovetti, for his papers on the direction of aerostats and on the resistance of the air.

IN connection with the preparation of argon, a good deal of attention has been paid to the absorption of nitrogen by metals. Prof. Ramsay, it will be remembered, used magnesium. Later, lithium was proposed by Ouvrard, and a mixture of lime and magnesium by Maquenne. The subject has recently been systematically investigated by Dr. Hempel, who finds that a mixture of calcium magnesium and sodium is very much more effective than the agents just named. The mixture is obtained by using 1 gramme of finely divided magnesium, 5 grammes coarsely powdered lime, and 0·25 grammes sodium. In a comparative time experiment the rates of absorption of nitrogen by magnesium, lithium, lime-magnesium, and lime-magnesium-sodium were in the ratio 1, 5, 8 and 20.

TO commemorate the completion of the twenty-five years of active work as a teacher of physiology of Prof. Purser, of Trinity College, Dublin, a movement is on foot among the professor's former pupils to raise funds for the bestowment annually of a "Purser Medal" to the candidate who, in the half M.B. examination, shows the highest proficiency in physiology and histology. Subscriptions, which are not to exceed a guinea, should be forwarded to the honorary treasurer, Dr. W. J. Houghton, 30 Lower Fitzwilliam Street, Dublin.

DR. MAXWELL T. MASTERS, F.R.S., has been made an officer of the Order of Leopold by the King of the Belgians.

THE Neill Prize for 1895-98 has been awarded to Prof. J. Cossar Ewart, F.R.S., by the Royal Society, Edinburgh, for his experiments and investigations bearing on the theory of heredity.

THE King of Sweden has conferred upon Mr. E. P. Martin, past-President of the Iron and Steel Institute, a Knight-commandership of the Royal Order of Wasa, and upon Mr. Bennett H. Brough, present Secretary of the Institute, a Knighthood of the same Order.

A DEPUTATION from the Iron and Steel Institute, consisting of Sir W. C. Roberts-Austen, K.C.B., F.R.S., President, Sir Lowthian Bell, Bart., F.R.S., Mr. E. P. Martin, past-Presidents, and Mr. Bennett H. Brough, Secretary, waited upon the Queen last week for the purpose of presenting to Her Majesty an illuminated address and the Bessemer Gold Medal, in commemoration of the great progress made in the iron and steel trade during the Queen's reign.

THE Meteorological Council have appointed Captain Campbell M. Hepworth, R.N.R., to fill the post of Marine Superintendent in succession to the late Mr. Baillie. Captain Hepworth has been an observer for the Meteorological Office for twenty-three years, and almost all of his logs have been classed "excellent."

A MEETING of the Aeronautical Society will be held at the Society of Arts to-morrow (July 28) at eight p.m.

THE summer meeting of the Institution of Mechanical Engineers was opened at Plymouth on Tuesday. In connection

with the meeting the Freedom of the Borough of Devonport has been presented to the president, Sir W. H. White, K.C.B., F.R.S.

THE thirty-sixth annual conference of the British Pharmaceutical Society of Great Britain was opened on Tuesday at Plymouth, the president, Mr. J. C. C. Payne, Belfast, being in the chair. The executive committee reported that the total membership was 1303. A number of papers on technical subjects were read and discussed.

THE Japanese Government have, it is stated, decided to make vaccination compulsory in Japan. All children must be vaccinated before the age of ten months. The first re-vaccination is to take place at six, and the second at twelve years of age.

MR. C. J. LYONS, writing in the U.S. *Weather Review*, from Honolulu, points out that most prominent volcanic outbursts on Hawaii have occurred at times of minimum sun-spots; so that, if the connection is real, a great lava flow may be expected at some time between now and 1901. Whether the years of maximum sun-spots are coincident with the years of no eruption does not appear to have been examined by Mr. Lyons.

A REUTER telegram of July 21 from New York states that the crater on the peak of Mauna Loa, Hawaii, burst into violent eruption on the 4th inst. Lava flowed down in three streams, one going towards Hilo and the two others in the direction of the sea, threatening the coffee plantations and the sugar lands.

A SPECIMEN of the egg of the Great Auk was sold by auction at Stevens's Rooms last week, and, although slightly cracked, realised the sum of 300 guineas, which equals the amount paid for the specimen sold at the same place in 1894. The egg just sold was figured in the *Memoirs* of the Société Zoologique de France in 1888, and, with additional notes on its history, it appeared in the *Bulletin* of the Société in 1891.

THE *Astrophysical Journal* for June states that a conference of astronomers and astrophysicists will, on the invitation of Prof. Hale, be held at the Yerkes Observatory, Williams Bay, Wis., U.S.A., from September 6 to 8 next. In its plan and scope the conference will be similar to those held in 1897 and 1898 at Williams Bay and Cambridge, Mass., respectively. The committee charged with perfecting a plan for the organisation of a permanent society of astronomers and astrophysicists, to have charge of future conferences, will present its report.

ACCORDING to the *Athenaeum*, Dr. Sven Hedin has set out upon his new journey of exploration in Central Asia, and expects to be absent for about two and a half years, principally in East Turkestan and the northern part of Tibet. The Russian Government has accorded him free passage on the Russian railway and free transmission of his very extensive equipment. For his Asiatic travel, as in his earlier journeys, a guard of Cossacks is to be placed at his disposal upon his application where necessary.

THE annual meeting of the British Medical Association will be held at Portsmouth next week. The proceedings will commence on Tuesday, August 1, when Dr. J. Ward Cousins, Southsea, will deliver the presidential address in the town-hall. On Wednesday and following days the sections will meet in the mornings and afternoons. On Wednesday evening a *soirée*, invitations to which will be issued by the president, will be held in the town-hall, and on Thursday the annual dinner of the Association will be held in the same building, to be followed by a reception organised by the ladies' committee. On Friday night Alderman T. Scott Foster will give a ball at the town-hall. The meeting will be brought to a conclusion on Saturday evening, August 5.

WE learn from *Science* that Clark University, Worcester, Massachusetts, has just celebrated its decennial in a manner worthy of a university devoted to the advancement of science. The following lectures were delivered in connection with the celebration: Prof. Ludwig Boltzmann, of the University of Vienna, on the "Principles and Fundamental Equations of Mechanics"; Prof. Picard, of the University of Paris, on "Differential Equations," and on "Analytical Functions"; Prof. Angelo Mosso, of the University of Turin, on "The Relation between Muscular Exercise and the Development of Mental Power," and on "Bodily Disturbances accompanying the Emotions"; Prof. Santiago Ramon y Cajal, of the University of Madrid, on the "Structure of the Visual Cortex of the Human Brain," and Prof. August Forel, of Zürich, on "Hypnotism," and on "Arts."

AN International Congress of Physics, to be held during the Paris Exposition next year, is being organised by a Committee of the Société française de Physique. The congress will commence on August 6, 1900, and will last a week. Though a number of special congresses are being arranged, it is thought that a congress having for its object the discussion of fundamental questions of physical science will be of interest to all physicists. Among the subjects to be dealt with in reports and discussions are the definition of certain units, such as pressure, scale of hardness, quantity of heat, photometric values, constants of saccharimetry, spectrum scale, and electrical units not yet defined; bibliography of physics; and national laboratories. There will also be visits to exhibits of scientific interest in the Exposition, to laboratories and to manufactories; and conferences on some new subjects, to be announced later, will be arranged. The president of the organising committee is Prof. Cornu; vice-president, M. Cailletet; and secretaries, M. C. E. Guillaume (au Pavillon de Breteuil, Sèvres, Seine-et-Oise) and M. Lucien Poincaré (105 *bis* boulevard Raspail, Paris), the former being the secretary for foreign members, and the latter for France.

FROM the *Bulletin de la Société d'Encouragement* we learn that an International Congress of Applied Mechanics has been organised for 1900 in connection with the Universal Exhibition. A draft programme has already been drawn up, and the subjects for discussion include mechanical laboratories, mechanical applications of electricity, high-speed steam engines, the mechanics of motor cars and implements. The Congress will open on July 19, 1900, and will last a week. Full particulars are obtainable from the Secretary of the Commission, 44 rue de Rennes, Paris.

THE Berlin correspondent of the *Lancet* gives a few particulars concerning the institution for the study of tropical diseases, shortly to be erected in Hamburg by the Government. It was the wish of Prof. Koch and the medical faculty that the institution should find a home in Berlin, in connection with, and as a department of, the Institution for Infectious Diseases. The Government, however, was of opinion that Hamburg would be preferable because a large number of patients coming from tropical climates and suffering from the specific diseases of the tropics are received into the Hamburg hospitals. In this way the new institution will have ample material for study, whilst if the institution were established in Berlin the patients would have to be conveyed from Hamburg and other seaports to the metropolis, a proceeding which would eventually be prejudicial to them. It is neither decided yet when the institution will be opened nor who will be appointed director. Probably one of the Colonial medical officers will be placed in charge.

According to the *Journal of Applied Microscopy*, it is proposed to hold a bryological meeting at Columbus, Ohio, during the session of the American Association for the Advancement of Science at that place. It is intended to present a series of papers, illustrated by specimens, photographs, microscopical slides, books and pamphlets, and to show the work done by leading workers on the subject. In addition to these will be shown collections of specimens, macroscopic and microscopic, illustrating the monographic work of living American students, and foreign students who have worked on North American mosses will be asked to co-operate.

The weather was very warm and dry last week, and the thermometer reached a higher point than on any previous occasion this summer. At Greenwich there were five consecutive days on which the shade temperature exceeded 80°, and on Wednesday and Friday the thermometer exceeded 88°. In some of the London suburbs the air temperature was highest on Friday, the 21st, the thermometer in Stevenson's screen touching 90° in the south of the metropolis. The highest temperature in the sun's rays at Greenwich occurred on Wednesday, when the thermometer registered 158°, which is higher than any reading during the previous three years. A sharp thunderstorm passed over the metropolis on Sunday morning, and the accompanying rainfall was generally heavy. At Greenwich the fall of rain exceeded three-quarters of an inch, at Westminster an inch was measured, while at Brixton the rain amounted to half an inch, and in some localities it was even less. A cooler air has spread over the British Islands during the last few days, and the general type of weather is favourable to occasional showers, so that at length the recent drought may reasonably be considered at an end.

The United States *Monthly Weather Review* for March contains an interesting historical account of the meteorological services in Russia, and especially of the Central Physical Observatory, by Prof. Cleveland Abbe, from which we extract the following notes. This institution is dependent upon the Academy of Sciences, which was established by decree of Peter the Great, dated January 22, 1718, and its first public session was held on January 7, 1726. Prof. A. T. Kupffer, born in 1798, was the first director and organiser of the meteorological system in Russia; his first volume of "Observations météorologiques et magnétiques" was published in 1837. Subsequent issues attracted the attention of the Emperor, who ordered that the work should appear as an annual volume under the title "Annuaire magnétique et météorologique." These volumes appeared up to that for 1846, which was published in 1849. In the meantime (April 13, 1849) the Emperor established the Central Physical Observatory, and the *Annuaire* thereafter appeared under the title "Annales de l'Observatoire Physique Central," and these were published up to the time of Kupffer's death in 1865. Thereupon Prof. Kämtz (born 1801) was called from Dorpat; but he died in 1867. His successor was Prof. H. Wild, born at Zürich in 1833. He held the directorship until July 1895, when he resigned on account of health; but he still remains an honorary member of the Academy of Sciences of St. Petersburg. During his administration a great impetus was given to all meteorological and magnetical work, and the volumes of the *Annales* 1865-9 were edited by him. With the volume for 1870 a new series, under the title "Annalen des Physikalischen Observatoriums," was begun, and under his auspices the new observatory at Pavlovsk was established for the purpose of scientific investigation. The appointment of General Rykatcheff (who began working with Prof. Kämtz in 1866) as director of the meteorological service in 1895 marks a general change in the spirit of administration of affairs in Russia, where the so-called Russian element is at present predominant. The memoirs bearing on the work of the observatory are now published in Russian by the Physical Section of the Academy of Sciences; while the observations properly so-called, consisting entirely of numerical tables, are published in separate volumes under the former title of "Annales de l'Observatoire."

An ingenious machine for printing in colours, invented by Mr. Ivan Orloff, chief engineer and manager of the Russian Government printing works at St. Petersburg, has just been set up in London, and a company has been formed to develop the use of the machine for supplying coloured illustrations for periodicals and books. In colour printing by the ordinary method the successive colours are applied one at a time as the preceding one becomes dry. By means of the Orloff machine the whole of the colours required in a picture are printed at a single turn of the cylinder. If a picture has to be printed in, say, four colours, four separate blocks are arranged around the curved surface of the cylinder. As each block passes a particular point, the roller carrying the colour required by the block is made to fall upon it by a system of cams. Each block thus receives the coloured ink intended for it in the course of a revolution of the cylinder. All the printing surfaces, as soon as they are inked, transfer their designs to a composition roller which they pass, and this in turn transfers the combined coloured design to a final surface or *forme* carried on the same cylinder as the separate blocks, and from this *forme* the fully-coloured picture is imprinted upon paper at one impression. The fundamental idea of the machine is thus to print the separate colours in succession upon a common surface, and then to use the single surface as the *forme* in the final printing. These operations go on continuously. The cylinder completes one revolution in one-twentieth of a minute, within which time every colour surface has been inked and re-inked with its proper colour, and has delivered the result to the *forme* to be impressed upon paper. The results are very effective, and the "register" is perfect, no matter how many colours are used. The machine appears to mark a distinct development of methods of printing in colours.

From the *Standard* of July 22 we learn that the Botanical Garden of the Vienna University can now boast of possessing specimens of a plant not to be found in any similar institution in the world, or, indeed, anywhere else in Europe or America. When the Austrian Expedition to Southern Arabia, under Prof. Dr. David Heinrich Müller, was out there last winter, Prof. Dr. Oskar Simony, son of the well-known geographer, succeeded in obtaining some incense bushes, notwithstanding that the Arabs keep the places where they grow a secret from Europeans. He brought them to Vienna alive, and they are now in full leaf.

In the *Mathematical Gazette* for June, published under the auspices of the Mathematical Association, Prof. F. Morley communicates a note on the sphero-conic, in which he gives a simplified proof of the bifocal property. Mr. S. A. Saunders calls attention to the paradoxical questions arising from the notion of motion *at* an instant, a conception which like pressure *at* a point involves a peculiar use of the word "at." Mr. R. F. Davis contributes a paper on "Porismatic Equations"; and there is the usual collection of problems and solutions and reviews of text-books.

Only one article in the new part of the *Quarterly Review* is of scientific interest; it deals with the important subject of climate and colonisation. The writer of the article, after surveying a selection of the literature of the subject, and commenting on the efforts that have been or are being made towards a better understanding of tropical diseases, says: "Europeans who settle in tropical countries must not expect to remain unchanged from generation to generation. Even when there is no intercrossing, although the main features may persist for a long while, the new surroundings gradually give their own

impress. In all countries where Europeans have settled, we find they have altered in temperament, ideas, and bodily features. The change is slow at first, because fresh blood constantly streams in from the mother country and perpetuates the original characters; but as the Colony grows older the immigration falls off, and the new settlers diverge further and further from the original type. We have no reason to dread this evolution; it is the outcome of adaptation; and when we consider the splendid physical characteristics of many of the native races which inhabit tropical regions, we may fairly conclude that such adaptation will lead to the development of new types no whit inferior to the old. When we further consider that man, modifying the environment and substituting his selection for that of nature, has been able to produce and to develop endless varieties of domestic animals which would never have come into existence under natural conditions, and would soon deteriorate or perish when out of their artificial surroundings, we may certainly believe that he can, by taking thought, escape many of those detrimental influences which irresistibly modify all other organic beings."

"THE Geology of the Coolgardie Goldfield" forms the subject of the third *Bulletin* of the Geological Survey of Western Australia, and it is written by Mr. Torrington Blatchford, Assistant Government Geologist. This goldfield was discovered in 1892, and in the course of six years over two thousand tons of ore have been crushed, yielding gold at the rate of 1 oz. 3 dwt. per ton. This has been derived mainly from quartz reefs and partly from "lode formations." The amount of gold obtained from the rich alluvial deposits has not been estimated. The district of Coolgardie consists of a mass of granite on the west, succeeded by a belt of hornblendic and talcose schists, the whole being intersected by igneous dykes. Recent superficial deposits cover a large portion of the field, and at the base of these there is in places a thin stratum of "cement," an auriferous conglomerate that has not yet proved of much economic value. Gold is found in pyrites in the altered schists bordering the acid dykes, and the material is traversed by numerous small quartz leaders forming "stockworks." Though much gold has been won from this source, the lodes are small and irregular. The quartz reefs occur principally in the schists, and they dip from 60° to 80° to the east. The water-supply of the region is a source of trouble and expense. With a rainfall of only seven inches no great supply can be expected, except by storing. Shallow wells yield limited supplies up to 4000 gallons per diem at a depth of 200 feet, but a good deal of the underground water is saline. Deep boring has been unsuccessful, and supplies have in some cases to be brought from a distance. An excellent coloured geological map, on a scale of an inch to forty chains, has been prepared by Mr. Blatchford and Mr. E. L. Allhusen. This is an index to a larger map which is published separately.

IN the *Philosophical Magazine* for July the Rev. O. Fisher deals with the residual effect of a former glacial epoch upon underground temperatures. The object of the paper is to examine whether traces of the effects left by a former glacial period upon underground temperatures are sufficient in amount to enable estimates to be made, from observations in deep wells and mines, of the lapse of time since the ice disappeared from the land. The author investigates the character of the traces which a former glaciation might be expected to leave behind, the principal one being a reduction of the gradient. From observations of the temperature of a well at Wheeling, U.S.A., combined with a certain assumption, the author estimates the time of the glacial period at 34,013 years. On the whole, however, he considers that the question as to whether there is any prospect of estimating the date of the glacial epoch from underground temperatures must be answered in the negative; nevertheless, the different gradients observed in different localities may possibly be attributable in a measure to glaciation.

IN No. 8 of the series of *Frammenti concernanti la geofisica* (Rome) Dr. Folgheraiter gives an interesting account of the singular magnetic effects produced by lightning on a house at Torre Nuova, which was struck on April 8 last. The observations led the author to conclude (1) that the lightning produced a large number of singular points and zones in the masonry, it being inadmissible that the individual stones should have been so highly magnetised before construction of the walls; (2) that while doubts have hitherto existed as to the possible formation of singular points in tufa, this question has now been answered in the affirmative; (3) the alternation in the polarities of the singular points and zones, even on the same piece of tufa, is noteworthy, but no connection has yet been established between these alternations and the mode of propagation of the electricity; (4) it is now amply proved that lightning produces marked magnetisation independently of the inductive action of terrestrial magnetism.

WE have received a paper by the Rev. F. S. Chevalier, S.J., published by the Zi-ka-Wei Observatory, on the navigation of the Upper Yang-tze. The author's knowledge of the river is chiefly derived from personal observation made during a voyage as far up as Ping-shan-hsien during the winter of 1897–98. He takes a much more hopeful view of the navigability of the Upper Yang-tze than did Lieut. Dawson, whose survey is reported on in the *China Sea Directory*. The three chief obstacles, in the form of rapids, are discussed in detail, and suggestions are made with the view of making their navigation practicable. M. Chevalier has in preparation a chart of the river from I-chang to his highest point, on a scale of 1/25,000.

THE debatable question of the diffraction of Röntgen rays forms the subject of some recent experiments described by Prof. H. Haga and Dr. C. H. Wind in the *Proceedings* of the Royal Academy of Sciences of Amsterdam. In such experiments it is better, in order to obtain greater intensity, to use narrow slits than to make the distances great. As the time of exposure varied from 29 to 200 hours, the apparatus had to be mounted on a heavy freestone block supported on the central pillar of the Physical Laboratory of the University of Groningen, where the experiments were made. The diffraction slit was 3 cm. high and 14 microns at the upper end, gradually narrowing to a width of a few microns. A careful examination shows a kind of broadening out of the image corresponding to the narrowing of the slit, and this it is considered can only be attributed to diffraction of the Röntgen rays. The authors give estimates of the wave-lengths of the rays lying between 0,12 and 2,7 Ångström units, but consider that they cannot succeed in making measurements instead of estimations of the wave-length until Röntgen tubes have been produced remaining in working order as long as those used, and giving out rays of much greater energy.

THOSE responsible for the "Guide to the Museum of Eton College," seem remarkably fond of displaying an acquaintance with technical terms. Why, for instance, in giving a list of the birds of Berkshire, was it necessary to encumber it with the subheadings "Neornithes," and "Carinatæ," seeing that all existing birds come under the former category, and all those of Europe under the latter? If the number of names were reduced, and the language somewhat simplified throughout, the *Guide* would be admirable for its purpose. The museum appears to be well arranged; and it is satisfactory to note that the authorities recognise the importance of making the local collection the most prominent feature.

THE report of the Magnetical and Meteorological Observations made at the Government Observatory, Bombay, for the year 1897 has just been issued, with an appendix.

MESSRS. ISENTHAL, POTZLER, AND CO., of Mortimer Street, have sent us a supplementary list of new radiographic instruments made by them. Attention is drawn to several pieces of apparatus of recent construction.

WE have received the prospectus of the "One and All" Flower-show, an exhibition of horticultural photographs, to be held at the Crystal Palace on August 14–19, under the auspices of the "Agricultural and Horticultural Association, Limited."

IN the number of the *Biologisches Centralblatt* for July 1, Dr. R. Keller finishes his review of recent advances in vegetable physiology and botany; and Dr. G. Lindner his account of the germs of Protozoa found in rain water.

THE *Cambridge University Reporter* for June 22 contains the annual report of the Botanic Garden Syndicate for the year 1898. Several interesting and important additions have been made to the Botanic Garden during the year.

IN the numbers of the *Agricultural Gazette of New South Wales* for May and June is a continuation of M. A. O'Callaghan's series of papers on dairy bacteriology. It contains a report, with illustrations, of the bacteriological condition of a number of butters produced in the Colony.

THE Trinidad *Bulletin of Miscellaneous Information* (Botanical Department, No. 19) contains a preliminary report by Mr. G. Massee on the cacao pod disease, which is rife in the Colony. Mr. Massee ascribes it to a fungus belonging to the Peronosporeæ.

IN the *Irish Naturalist* for July is a synopsis of the Irish Characeæ, by Prof. T. Johnson; a paper on some algæ from the Antrim coast, by H. Hanna; and one on some freshwater mites from Co. Dublin, by D. Freeman.

THE *Transactions* of the Manchester Microscopical Society contains several papers which show a record of good work in microscopy:—The genitalia and radulæ of the British Hyalinia, by W. Moss; *Peripatus Leuckarti*, by F. Paulden; Scale insects, by A. T. Gillanders; *Myriothela Phrygia*, a tubularian hydroid, by W. Blackburn; and others.

WE have received a copy of Dr. Gunnar Andersson's "Studies of the Quaternary Flora of Finland" (*Bulletin de la Commission Géol. de Finlande, Helsingfors*, 1898). The work is accompanied by four excellent plates of fossil seeds, and it contains descriptions and sections of the peaty deposits from which they have been obtained.

THE current issue of the *Reliquary and Illustrated Archaeologist* contains many interesting contributions, among which may be mentioned "Antiquities of Bolsterstone and Neighbourhood," "The Instrument of the Rosary," "Two Midlothian Souterrains," "The Grinlow Barrow, Buxton," and "Notes on Archæology and Kindred Subjects." As is usual in this magazine the articles are well illustrated.

MR. ARTHUR S. EAKLE describes some andesites from the Fiji Islands (*Proc. Amer. Acad. Arts and Sciences*, May 1899). Augite-andesite seems to be the predominating rock of the islands, and it varies from types having a small amount of augite with a large amount of felspar, and with biotite as an accessory, to those in which augite is the dominant constituent, thus showing a gradation into basalt.

VOL. II., part 6, of the serial form of C. E. Groves's translation of Fresenius' "Quantitative Analysis" has now been brought out by Messrs. J. and A. Churchill; the University Correspondence College has issued its Matriculation Directory dated June 1899, in which will be found articles on the special subjects for January and June 1900; a new edition of "The Arithmetic of Electrical Measurements," by W. R. P. Hobbs, has been issued by Murby. The work has been revised and in part re-written.

THE additions to the Zoological Society's Gardens during the past week include an Anubis Baboon (*Cynocephalus anubis*, ♀) from Accra, presented by Mr. G. B. Haddon Smith; a Feline Dourocouli (*Nyctipithecus vociferans*) from Brazil, presented by Mrs. Arthur Harter; a Ring-tailed Lemur (*Lemur catta*) from Madagascar, presented by Mrs. T. Butt Miller; a Spotted Ichneumon (*Herpestes auro-punctatus*) from Malacca, presented by Mr Geo. F. Aress; a Levaillant's Cynictis (*Cynictis penicillata*), two Bristly Ground Squirrels (*Xerus setosus*) from South Africa, presented by Mr. J. E. Matcham; a Common Duiker (*Cephalophus grimmi*, ♂) from South Africa, presented by Captain G. C. Denton; two Cormorants (*Phalacrocorax carbo*) from Scotland, presented by Mr. P. L. Pemberton; a Ground Hornbill (*Bucorvus abyssinicus*) from West Africa, presented by Mr. Geo. Hirst; two Blood-rumped Parrakeets (*Psephotus haematonotus*) from Australia, presented by Mrs. A. Chambers; a Golden Eagle (*Aquila chrysaetus*) from Scotland, presented by Mr. H. C. Ross; three Adorned Terrapins (*Chrysemys ornata*) from Mexico, presented by Mr. C. J. Rickards; a Burchell's Zebra (*Equus burchelli*, ♀) from South Africa, two Hairy Armadillos (*Dasypus villosus*) from La Plata, a Lion Marmoset (*Midas rosalia*) from South-east Brazil, a Blue-fronted Amazon (*Chrysotis aestiva*) from South America, deposited; a Chattering Lory (*Lorius garrulus*) from Moluccas, purchased; two Collared Fruit Bats (*Cynonycteris collaris*), a Burrhel Wild Sheep (*Ovis burrhel*), born in the Gardens.

## OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL OCCURRENCES IN AUGUST:—

August 2. 11h. 25m. Minimum of Algol ($\beta$ Persei).
11. Maximum of the August meteoric shower of Perseids.
14. 8h. 25m. to 9h. 37m. Occultation of the star D.M. − 22°, 3989 (mag. 6) by the moon.
14. 9h. 4m. Transit (immersion) of Jupiter's Sat. III.
15. Illuminated portion of the disc of Venus 0·989, of Mars 0·949.
18. 10h. 28m. to 11h. 34m. Occultation of *f* Sagittarii (mag. 5·1) by the moon.
22. 9h. 21m. to 10h. 15m. Occultation of 16 Piscium (mag. 5·6) by the moon.
22. 15h. 1m. to 16h. 8m. Occultation of 19 Piscium (mag. 5·2) by the moon.
23. Outer minor axis of Saturn's outer ring = 17″·94.
25. 9h. 57m. Minimum of Algol ($\beta$ Persei).
26. 12h. 5m. to 13h. 5m. Occultation of $\tau^2$ Arietis (mag. 5·2) by the moon.
26. 12h. 55m. to 13h. 51m. Occultation of 65 Arietis (mag. 5·6) by the moon.
27. 16h. 20m. to 17h. 19m. Occultation of $v^1$ Tauri (mag. 4·6) by the moon.
27. 16h. 49m. to 18h. 9m. Occultation of $v^2$ Tauri (mag. 5·5) by the moon.
29. 16h. 9m. to 17h. 25m. Occultation of $\eta$ Geminorum (mag. variable) by the moon.
30. 14h. 59m. to 15h. 58m. Occultation of $\zeta$ Geminorum (mag. variable) by the moon.

TEMPEL'S COMET 1899 *c* (1873 II.).

*Ephemeris for 12h. Paris Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ ″ | Br. |
|---|---|---|---|
| July 27 | 20 47 55·4 | −21 56 9 | 3·698 |
| 28 | 49 6·7 | 22 29 17 | |
| 29 | 50 18·0 | 23 2 17 | |
| 30 | 51 29·2 | 23 35 4 | |
| 31 | 52 40·5 | 24 7 36 | 3·673 |
| Aug. 1 | 53 51·8 | 24 39 49 | |
| 2 | 55 3·2 | 25 11 40 | |
| 3 | 20 56 14·6 | −25 43 7 | |

The comet is now as bright as it is expected to become according to computation, and moreover is rapidly moving southwards, so that it will soon be beyond the reach of observers in these latitudes. During the week it passes from a position near the 6th mag. star 17 Capricorni to the vicinity of the 4th mag. red star A Capricorni.

Stellar and Nebular Spectra with Concave Grating.—In the earlier part of 1898 Messrs. Poor and Mitchell described the results of their attempts to photograph stellar spectra with a Rowland concave grating (*Astro-Physical Journal*, 8, p. 157). The grating used was a small one, having a ruled surface of only 1 × 2 inches with 15,000 lines to the inch, the radius of curvature being about 1 metre. Later a special grating was made with a ruled surface $2 \times 5\frac{3}{4}$ inches, having 7219 lines to the inch. The radius of curvature of this was also 1 metre. The instrument was mounted on the 9·3-inch Hasting's refractor as guiding telescope, and the results obtained were very promising, although the observatory is on the *sixth* floor of the Physical Laboratory at Baltimore. In November 1898, however, by the kindness of Prof. Hale, it became possible for Mr. Mitchell to mount the grating on the 12-inch Brashear refractor of the Verkes Observatory (*Astro Physical Journal*, x. pp. 29–39, 1899). It will be remembered that the grating is used "*direct*," the concave surface bringing the diffracted beam from the star to focus on the plate, and that a considerable advantage obtains in that the spectra obtained are *normal.* The grating was so oriented that the lines were parallel to the equator, so that irregularities in the driving-clock should have no effect on the definition. The astigmatism alone not being sufficient to give the spectrum sufficient width, this was effected by allowing the star to trail in right ascension. Photographs of the spectra of a large number of stars have been thus obtained, with exposures varying from 5 to 60 minutes. These are given in a table in the article. Of special interest is the fact that these photographs show the ultra-violet region remarkably well, as is to be understood when it is remembered that the light has to traverse neither lenses, prism trains nor slit. The photograph of Sirius showed about 75 lines between $H\beta$ and $H\gamma$, and in the ultra-violet 21 lines of the series due to hydrogen were measured.

In February two very interesting photographs of the spectrum of the Orion nebula were obtained with exposures of about 200 minutes. Just as with an objective prism, these spectra consist of a series of images of the nebula, the measures of corresponding regions of which give the wave-lengths of the various lines they represent.

With the grating used, the length of the photographic region in the first order was about $1\frac{1}{4}$ inches, using Seed's gilt edge plates. In the second order the distance from $H\beta$ to $H\gamma$ was 0·6 inch, and from $H\beta$ in the first order to $H\beta$ in the second was 2·8 inches. The photographic plate used, 1 × 5 inches, thus included both spectra, and their duplicate measurement afforded a definite control over the wave-lengths determined.

Attention is directed to the fact that the spectra being *normal*, absolute measurements of wave-length, and therefore of motion in line of sight, may be determined when larger instruments of this kind are available. A grating with ruled surface 10 × 15 inches would probably be fully equal in performance to any spectroscopes in present use.

## *THE REASON FOR THE HISSING OF THE ELECTRIC ARC.*[1]

### II.

And now we come to the most important of all the changes that take place when the arc begins to hiss, viz. the alteration in the shape of the *positive* carbon.

During the course of his 1889 experiments, Luggin (*Wien Sitzungsberichte*, 1889, vol. xcviii. p. 1192) observed that the arc hissed when the crater filled the whole of the end of the positive carbon. He was thus the first to call attention to the fact that there was a direct connection between hissing and the relation between the area of the crater and the cross-section of the tip of the positive carbon. My own observations in 1893 led to a conclusion somewhat similar to Luggin's, but yet differing in an important particular. It seemed to me that, with hissing arcs, the crater always *more* than covered the end of the positive carbon—that it overflowed, as it were, along the side. How far this is true will be seen from an examination of Figs. 4, 5, 6 and 7, which show the shaping of the carbons under various conditions with silent and hissing arcs. These figures have all been made from tracings of the images of actual normal arcs, burning between carbons of various sizes, and they were carefully chosen with special reference to the shaping of the positive carbons. For, with normal arcs, the shape of the end of a positive carbon, even taken quite apart from that of the negative carbon and of the vaporous arc itself, is capable of revealing almost the whole of the conditions under which the arc was burning when it was formed. It is possible, for instance, with a normal arc, to tell, from a mere drawing of the outline of the positive carbon and of its crater, whether the arc with which it was formed had been open or enclosed, short or long, silent or hissing, burning with a large or with a small current for the size of the carbon.

Take, for example, Fig. 4 (see p. 285, July 20), and note the difference in the shape of the positive carbon with a current of 3·5 amperes, as in (*a*), and with one of 34 amperes, as in (*b*). In the first case the tip of the positive carbon is rounded, so that the crater lies in its smallest cross-section; in the second, the tip would be practically cylindrical for some distance, but that the crater has burnt away a part of the cylinder, making the tip look as if it had been sheared off obliquely. Comparing now the tips of the positive carbons when the arc is silent and when it is hissing in all the four figures, 4, 5, 6, 7, we find the same difference. With all the silent arcs the tip is more or less rounded, and the crater lies in its smallest cross-section, and consequently is less in area than any but the smallest cross-section. With all the hissing arcs, on the other hand, the tip of the positive carbon is practically cylindrical for a short distance at least, or would be but that it is sheared away by the crater; consequently the area of the crater is *greater* than the smallest cross-section of the tip, or, indeed, than the cross-section of the tip for some little distance along its length.

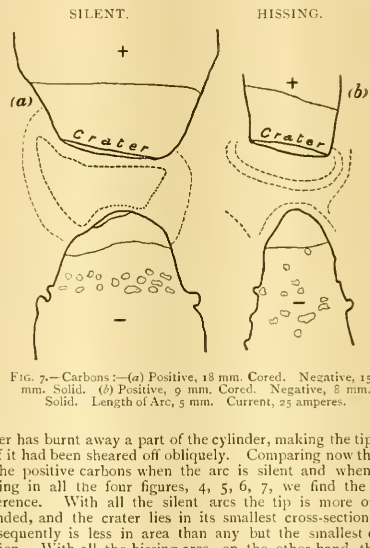


Fig. 7.—Carbons:—(*a*) Positive, 18 mm. Cored. Negative, 15 mm. Solid. (*b*) Positive, 9 mm. Cored. Negative, 8 mm. Solid. Length of Arc, 5 mm. Current, 25 amperes.

We have now arrived at the real, the *crucial*, distinction between a silent and a hissing arc. When the crater occupies the *end* of the positive carbon only, the arc is *silent*; when it not only covers the end, but also extends up the *side*, the arc *hisses*. Hence, the arc must be at the *hissing point* when the smallest increase in the area of the crater will make it begin to cover the *side* of the positive carbon, and this can only be when the tip of that carbon has very nearly the same cross-section for some little distance from its end—in other words, when its sides are nearly vertical.

I shall now proceed to show that the extension of the crater up the side of the positive carbon is not the *effect* but the *cause* of hissing; that, in fact, *hissing is produced by the crater be-*

[1] Based on a paper read before the Institution of Electrical Engineers by Mrs. W. E. Ayrton. (Continued from page 286.)

*coming too large to occupy the end only of the positive carbon, and therefore extending up its side.*

Simple as is this explanation of a very complicated series of phenomena, it is the true one; but before proceeding to demonstrate its truth it will be interesting to see how the laws for the largest silent currents with normal arcs, which have already been obtained from the electrical measurements on pp. 283, 284, may be deduced on the above hypothesis from Figs. 6 and 7.

In Fig. 6 (p. 285) we have a series of four normal arcs of the same length burning between solid carbons of the same diameter; but in (*a*) the current is 6 amperes, in (*b*) 12, in (*c*) 20, and in (*d*) 30 amperes. The bluntness of the tip of the positive carbon may be measured by the obtuseness of the angle A B C. In (*a*) the tip is very blunt, and the area of the crater is certainly less than any but its smallest cross-section; therefore the arc is certainly silent. In (*b*) the tip is less blunt, but the arc is still evidently silent; in (*c*) the angle A B C is much more nearly a right angle, and it is plain that a very small increase in the area of the crater would cause it to burn up the side of the tip; therefore the arc is near the hissing point. In (*d*) the angle A B C is practically a right angle, the tip of the positive carbon is cylindrical, and the crater has evidently burnt partly up its side. Thus with a normal arc, keeping the length of the arc constant and gradually increasing the current, must bring us to a hissing point.

This brings me to the reason for the great importance of distinguishing between arcs that are normal and those that are not. For although, with normal arcs of any given length, hissing only starts when the current is *greater* than it can be with any silent arc of the same length, with a *non*-normal arc of 2 mm. I have been able to produce hissing with a current of 11 amperes, and to have a silent arc burning with a current of 28 amperes, the same carbons being used in each case.

The reason of this is obvious. When the arc is normal, the carbon ends and crater have a perfectly definite size and shape corresponding with each current and length of arc, and changes in these are made slowly, so as to allow time for the carbons to assume their proper form in each case. If, however, the current be *suddenly* much increased, when, say, the carbons have previously been very pointed, then the area of the crater may increase so rapidly that it will extend up the side of the carbon and cause hissing, even although the carbons would have shaped themselves so that there would have been room for the crater to remain at the end of the carbon if the change had been made more gradually.

Suppose, for instance, the end of the positive carbon were filed to a long fine point, then a very small current would make a crater large enough to extend up the side of the point, and produce a hissing arc. If, on the contrary, the end were filed flat, so as to have as large a cross-section as possible, quite a considerable current could flow silently even with a short arc, for in that case it would require the current to be very great for the crater to be large enough to fill up the whole of the end of the positive carbon.

Next, I have shown elsewhere (*The Electrician*, 1895, vol. xxxiv. p. 614) that, with a constant current, the end of the positive carbon becomes rounder and blunter, and occupies a larger portion of the entire cross-section of the carbon rod, the more the carbons are separated. Hence the longer the arc the greater must be the area of the crater, and consequently the greater must be the current, before the crater extends up the side of the positive carbon. Consequently, the longer the arc the greater is the largest silent current.

Thirdly, it follows that when the current and the length of the arc have been increased to such an extent that the round, blunt tip of the positive carbon occupies the whole cross-section of the carbon rod itself, no further increase in the size of the crater is possible without a part of it extending up the side of the carbon. Hence the largest silent current for a positive carbon of a particular diameter cannot exceed a particular value, however long the arc may be made. And lastly, similar reasoning, used in conjunction with Fig. 7, tells us that the thicker the positive carbon the greater must be the largest current that can flow silently with a particular length of arc, which was one of the results deduced from the curves in Figs. 2 and 3.

Thus the fact that hissing occurs when the crater covers more than the end surface of the positive carbon and extends up its side, combined with our knowledge of the way in which the positive carbon shapes itself in practice, is sufficient to enable us to deduce *all* the laws given on pp. 283, 284 which govern the largest current that will flow silently with the *normal* arc under given conditions.

We come now to the question, why should the arc hiss when the crater burns up the side of the positive carbon—what happens then that has not happened previously?

In pondering over this question, the possibility occurred to me that as long as the crater occupied only the *end* surface of the positive carbon it might be protected from direct contact with the air by the carbon vapour surrounding it, but that, when the crater overlapped the side, the air could penetrate to it immediately, thus causing a part at least of its surface to *burn* instead of volatilising. Many circumstances at once seemed to combine to show that this was the true explanation. The dancing circles I observed, and Mr. Trotter's stroboscopic images, how were they caused but by draughts getting into the arc? Then the humming noise, which sounds like the wind blowing through a crack, was not this probably caused by the air rushing through a slight breach in the crater, already getting near to the critical size? This air pouring in faster and faster as the breach widened would cause the arc to rotate faster and faster, sometimes in one direction, sometimes in another, according as the draught was blown from one side or the other. Then, finally, the air would actually reach the crater, burn in contact with it, and the P.D. would fall and the arc would hiss.

In the open arc, whether silent or hissing, the outer envelope of the vaporous portion is always bright green. With the hissing arc the light issuing from the *crater* is also bright green or greenish blue. What so likely as that the two green lights should have a common origin, viz. the combination of carbon with air? For the outer green light is seen just at the junction of the carbons and carbon vapour with the air, and the inner one only appears when air can get direct to the crater.

Again, why does the arc always hiss when it is first struck? Is it not because a certain amount of air must always cling to both carbons when they are cold, so that when the crater is first made its surface must combine with this air?

The cloud that draws in round the crater when hissing begins would be a dulness caused by the air cooling the part of the crater with which it first came into contact, the bright spots being at the part where the crater and air were actually burning together. In fact everything seemed to point to the direct contact of crater and air as being the cause of hissing and its attendant phenomena.

One easy and obvious method of testing this theory immediately presented itself. If air were the cause, exclude the air, and there would be no sudden diminution of the P.D. between the carbons, however great a current might be used. Accordingly I tried maintaining arcs of different lengths in an enclosed vessel, and increasing the current up to some 40 amperes. *No* sudden diminution of the P.D. could be observed with any of the currents or lengths of arc employed, although when the same carbons were used to produce *open* arcs, the sudden diminution of 10 volts in the P.D. between the carbons occurred with a current as low as 14 amperes for a 1 mm. arc.

It was, of course, impossible, in these experiments, to avail myself of an ordinary enclosed arc lamp, such as is used for street lighting, since a current of only some 5 or 8 amperes is all that is used with such a lamp, whereas to test my theory it was necessary to employ currents up to 40 amperes. Accordingly I constructed little electric furnaces of different kinds, one of which is shown in Fig. 8.

Some curves connecting the P.D. between the carbons with the current when the arc was completely enclosed in the crucible (Fig. 8) are given in Fig. 9. The carbons were similar to those used with the open arc experiments (Fig. 1, p. 282), being solid, the positive 11 mm. and the negative 9 mm. in diameter. As this crucible—the first one made—had no window, the length of the arc could not be kept quite constant, but the distance by which the carbons were separated was noted at the beginning of the experiment, and they were then allowed to burn away, without being moved, till the end, when the distance the positive carbon had to be moved in order to bring it tightly against the negative was noted. Measured in this way, the length of the arc was 1·5 mm at the beginning and 2 mm. at the end of the experiment. The current was started at 6 amperes, and gradually increased to 39 amperes; then as gradually diminished to 6 amperes again, increased to 36 amperes, and diminished to 5 amperes, when the arc was extinguished. The

P.D. between the carbons for a given current seems to have increased as the length of time during which the arc had been burning increased; this was undoubtedly partly due to the lengthening of the arc, but was probably also partly due to the whole of the air in the pot having been gradually burnt up or driven out through the slag wool and the asbestos ring by the pressure of the carbon vapour.

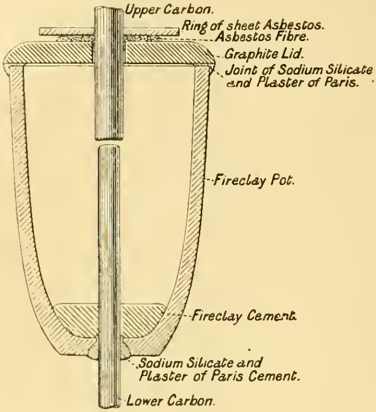


FIG. 8.

Many other sets of curves were obtained, but all with the same result, viz. that when once the crucible had been freed from air, no sudden diminution in the P.D. could be observed on increasing the current far beyond the value at which this diminution occurred on lifting up the lid and allowing the air to have access to the arc.

The next thing to do was to try if an open arc could be made to hiss and the P.D. to diminish suddenly by blowing air at the lege, suggested using a tubular positive carbon and blowing the air down it. This plan answered admirably, for when a current of 10 amperes was flowing with an arc of about 3 mm., so that the arc was quite silent, each puff of air blown down through the positive carbon was followed by a hiss and the characteristic diminution of the P.D. between the carbons. With a current of 6 amperes, however, I could get no hiss, but simply blew the arc out each time, probably because, with such a small current, the arc was cooled sufficiently to be extinguished before the action could take place.

Oxygen was next tried, still with the open arc, and again each puff produced a hiss and diminution of the P.D., the latter being exactly the same in amount as when air was used, namely, about 10 volts. As my idea was that the diminution of the P.D. was due to the chemical combination of air with carbon at the temperature of the crater, the fact of oxygen producing the same diminution as air seemed to show that nitrogen would produce no effect, and that all the effect produced by air was due to the oxygen in it. Accordingly I tried blowing nitrogen down the positive carbon of an open arc, and found that *no* change in the P.D. followed if the nitrogen was blown through gently, but that, beyond a certain pressure, the arc was blown to one side, and thus lengthened, so that the P.D. *rose* as it always does when the arc is lengthened, and, if the pressure continued, the arc went out.

This experiment proved two things—firstly, that it is the *oxygen* in the air that causes the diminution in the P.D. with hissing; secondly, that this diminution is not due to cooling, for nitrogen would cool the arc as effectually as oxygen or air.

To make assurance doubly sure on this point, carbon dioxide was blown down the tubular positive carbon, with the same result as when nitrogen was used, viz. no change was produced in the P.D. between the carbons unless the pressure of the gaseous stream were large enough to blow the arc on one side, and then an increase and not a diminution in the P.D. was observed.

If, however, the current was *very near* the value that made an open arc of the particular length used start hissing, blowing either nitrogen or carbon dioxide through the positive carbon sometimes started hissing; but this was due, *not* to any direct action of the stream of gas on the carbon, but to the arc being deflected by the gaseous stream and burning obliquely up the side of the carbon, and thus allowing the air to come into contact with the crater. The proof of this was that this diminution in the P.D. had the same value as if air had been

ARC ENCLOSED IN CRUCIBLE.

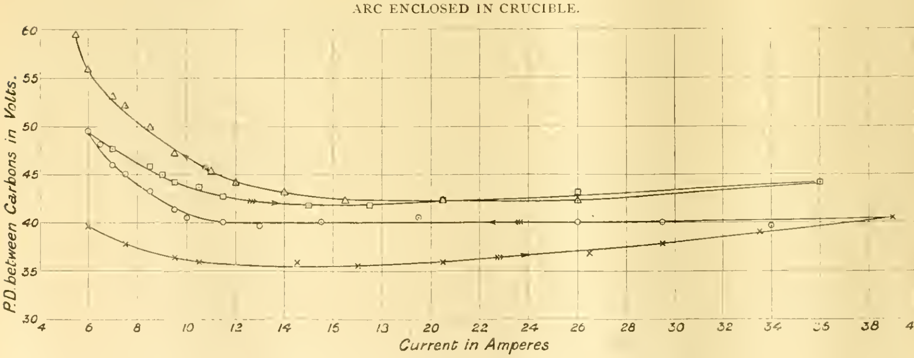


FIG. 9.—Curves connecting P.D. and Current for nearly Constant Length of Arc of 1·5 mm. to 2 mm. The arrows show the direction in which the Current was varied. Carbons:—Positive, 11 mm. Solid; Negative, 9 mm. Solid.

crater, when the current was so small that the crater remained well at the end of the positive carbon—in fact, to bring the air in contact with the crater artificially when a much smaller current was flowing than would usually produce hissing. I first tried inserting a carbon tube in the arc, and blowing through it, but this almost invariably blew the arc out. Then Mr. Phillips, one of Prof. Ayrton's assistants at the Central Technical Col- employed, and that the hissing did not cease when the stream of nitrogen or of carbon dioxide was stopped.

This was not the case with hydrogen, however. When that gas was blown down the positive carbon in the open air, the arc would start hissing, if the current were large enough, *and stop hissing the moment the hydrogen was shut off.* Not only this, but the diminution in the P.D. had a different value from

that produced by air, being only about 6·6 volts, or about $3\frac{1}{2}$ volts lower than when the hissing was caused by air alone.

In order to exclude all possibility of doubt as to the effect of the various gases, I repeated the experiments with the arc entirely enclosed in one of the fire-clay crucibles, so that the only gases that could reach the crater were those blown down the tubular positive carbon. The current was distinctly below the hissing point, being only 10 or 11 amperes, and the arc was from 2 mm. to 3 mm. long.

The results were exactly the same as with the open arc, except in the case of hydrogen. For air and oxygen produced hissing and a sudden diminution of the P.D., and nitrogen and carbon dioxide had no such effect, even when the current was very much increased. But whereas, as has been previously stated, hydrogen produced a distinct hissing of its own when blown down the positive carbon in the *open air*, it produced *none* when used in the same way with the arc *enclosed* in the crucible.

To prove that, in order to produce the sudden diminution of P.D under discussion, it was necessary for the active gas to actually *touch* the crater, a tubular *negative* carbon was used, and each gas was blown up through it in turn, gently enough not to force the gas directly against the crater.

In *no* case was there any sudden diminution of the P.D., whatever gas was employed, and whether the arc was open or enclosed. On the contrary, there was generally a small increase, probably due to the lengthening of the arc by its being blown on one side. If oxygen or air were blown *very hard* up the negative carbon, they would either produce hissing, or blow the arc out, or both; for in that case some of the gas got to the crater uncombined with the carbon vapour, and acted exactly as if it had been blown do ·n the tubular positive carbon.

The case, then, stands thus:

(1) When the arc begins to hiss in the ordinary way, the P.D. between the carbons diminishes by about 10 volts.

(2) If the air is excluded from the arc, this diminution of the P.D. does not take place, even when the current is nearly three times as great as would cause hissing in the air.

(3) If, however, while the air is excluded, puffs of air are sent against the crater, the diminution of the P.D. *does* occur, even with currents much *smaller* than would cause hissing in the air.

(4) If, instead of air, *oxygen* is sent against the crater, the P.D. is diminished to exactly the same extent as when air is used.

(5) If, on the other hand, *nitrogen* is sent against the crater, *no* diminution of the P.D. is observable.

(6) If air or oxygen is gently blown through the *negative* carbon, so that it cannot get direct to the crater, *no* diminution of the P.D. follows.

Thus there can be no shadow of doubt that *the sudden diminution of P.D. that accompanies the hissing of the open arc is due to the oxygen in the air getting directly at the crater and combining with the carbon at its surface.*

It only remains to show how the actual hissing *sound* may be produced by the burning of the surface of the crater. The moment this burning begins, a cloud of gas, formed of the products of combustion, must spread over the crater, protecting it momentarily from the action of the air as effectually as the carbon vapour had hitherto done. When this gas is dispersed, the air will again come in contact with the crater, a fresh cloud will form, and the whole action will start *de novo*. Thus a series of rushes and stoppages of the air will take place, setting up an irregular vibration of just the kind to cause a hissing noise. Not only this, however, but since the crater must cease to burn each time that it is protected by the gas, the diminution of P.D. must also cease to exist, since its cause is removed, and the P.D. will therefore rise momentarily. Thus an oscillation of the P.D. between the carbons, and, consequently, of the *electric* current, must be created, corresponding with the oscillation of the *air* current.

These oscillations of both air and electric currents do actually exist with the hissing arc. The first I have proved by means of a fine asbestos fibre fastened at one end to the hole in the crucible (Fig 8) through which the positive carbon moved. The asbestos ring was raised, and the space between the carbon and the crucible was left clear, and was made large enough to allow the free end of the short fibre to stretch out horizontally between the two. When the arc was silent, the fibre scarcely moved, but the moment hissing started it set up a vigorous vibration, instead of being sucked into the crucible as it would have been if there had been a steady inward current of air.

Messrs. Frith and Rodgers (*Phil. Mag.*, 1896, p. 420) showed, in 1896, that the *electric* current was oscillatory with the hissing arc, and Messrs. Duddell and Marchant (*Journ. Inst. Elec. Engs.*, vol. xxviii. p. 84) in the account of their beautiful experiments with the oscillograph, have given actual curves of the P.D. and current with the direct current hissing arc, showing distinctly the oscillations in both.

Thus the direct contact of the oxygen of the air with the crater of the positive carbon is capable of producing, not only the diminution of the P.D. between the carbons of the arc, which is the most striking accompaniment of hissing, but also every other important manifestation connected with it, including the sound itself.

HERTHA AYRTON.

## THE INTERNATIONAL CONFERENCE ON HYBRIDISATION AND CROSS-BREEDING.

IN this country where the application of biological principles to the industries which they underlie is left as a rule to private enterprise or the half-hearted interest of County Councils, any means whereby the scientific worker is shown to be useful to the practical man is a help towards a better state of things.

For this reason alone the Conference on Hybridisation suggested by Mr. W. Bateson, and held on July 11 and 12, under the auspices of the Royal Horticultural Society, may have more importance in the future than Prof. Henslow claimed for it in the present. The more immediate results that will accrue are those which the Society foresaw must arise if the attempt to call forth papers, remarks and exhibits dealing with hybridisation was at all successful. Two days were not many to devote to the meeting, and it is a matter of surprise that such an amount of work was done in the time. When, however, the whole of the contributions, whether read or unread at the conference, are published in the form of an illustrated report, the Royal Horticultural Society should be more than satisfied.

Nevertheless the question of hybridisation is so large, as Mr. Engleheart said in the discussion, that "whole sets of subjects" (graft hybrids, for instance) could not even be touched upon, and the suggestion made in several quarters, but by the American delegates in particular, that a supplementary conference be held in another country should be taken up seriously.

Before discussing the chief points of the meetings it may be of interest to give a list of the speakers and their subjects.

Tuesday, July 11, in the Society's Gardens at Chiswick:—

(1) Maxwell T. Masters, F.R.S., Introductory remarks as Chairman.

(2) W. Bateson, F.R.S., "Hybridisation and Cross breeding as a Method of Scientific Investigation."

(3) A. de la Devansaye, "Hybrid Anthuriums"

(4) Prof. Hugo de Vries, "Hybridisation as a means of Pangenetic Infection."

(5) The Rev. Prof. Henslow, "Hybridisation and its Failures."

(6) C. C. Hurst, "Experiments in Hybridisation and Cross-breeding."

Wednesday, July 12, at the Town Hall, Westminster.

(1) The Rev. Prof. Henslow, Introductory remarks as Chairman.

(2) Herbert J. Webber, "Work of the United States Department of Agriculture in Plant Hybridisation."

(3) Dr. J. H. Wilson, "The Structure of certain New Hybrids (*Passiflora*, *Albuca*, *Begonia*, &c.)"

(4) R. Allen, "Hybridisation viewed from the Standpoint of Systematic Botany."

(5) Henry de Vilmorin, "Hybrid Poppies."

(N.B.—Nos. 2 and 3 were illustrated by means of lantern slides, and No. 5 by large water-colour drawings.)

(6) Discussion; Prof. Henslow, Mr. Burbidge, Rev. G. H. Engleheart, Mr. George Paul, Mr. Bunyard, Dr. Masters, Mr. Willet Hays, and Mr. W. Cuthbertson.

The United States was represented by Mr. Herbert Webber, of the Department of Agriculture, his colleague Mr. Swingle, and Mr. Willet Hayes; France by MM. de la Devansaye

and Vilmorin; while among other "friends from across the sea" were hybridists from Germany, Holland and Switzerland.

With regard to the main body of our own countrymen who attended the conference, it must be said that horticulturists were very well represented, but that, with the exception of the readers of papers, biologists were few and far between.

Among papers of interest that were not read at the conference, but will appear in the report, the following may be mentioned:—

Prof. L. H. Bailey, "Progress of Hybridisation in the United States of America."
F. Morel, "Hybrids of *Clematis*."
P. Chappellier, "Essay on the Hybridisation of *Dioscorea*."
Émile Lemoine, "Hybrids of the Common and Laciniated Persian Lilacs."
L. Henry, "The Records of Hybridisation Experiments made at the Paris Natural History Museum between 1887 and 1899."
Charles T. Druery, "Fern Crossing and Hybridising."
Dr. Charles Stuart, "Hybrids of *Mimulus*, *Viola*, *Acquilegia*, &c."

During the first day's proceedings a fine show of hybrid plants and intergrafted genera was exhibited in the vinery at Chiswick.

Turning now to the material laid before the conference, it will be best to consider details under special headings.[1]

## I. THE QUESTION OF SPECIES.

*Significance of the Conception.*—As the word hybrid ordinarily means the result of a cross between two species, it follows almost necessarily that the question of what a species is was several times raised. Prof. Henslow was so bold as to give a definition, saying that "it is known by a collection of presumably constant characters taken from any or all parts of the plant."

It is necessary to have some idea for working purposes, but Dr. Masters came rather nearer to the mark when he said that the species once considered sacred, to-day practically represented the personal opinion of some man who had paid special attention to it.

Mr. Bateson again still clung to the opinion that species were often definite, but breeding work alone, he said, could throw light upon the subject. He contended that this had already shown that under the title of species and varieties "whole sets of (physiologically) distinct phenomena are confused together," and taking it as proved that species arise from discontinuous variations, he gave three instances where the same deviation from type was kept up discontinuously, but in three different ways:—

(*a*) The hairy wild form of *Matthiola incana* from the Isle of Wight was crossed with the smooth wallflower variety of the stock.
The offspring fell into two groups, and from the same capsule came one hairy and three smooth plants.

(*b*) The usual hirsute type of *Lychnis vespertina* and the hairless form cultivated by Prof. Hugo de Vries were bred together.
The offspring were all hairy, but on being left to fertilise each other, the second generation gave some hairy, some smooth individuals.

(*c*) The variations of *Biscutella laevigata* which occur in Switzerland, one with hairs and the other without (connected by but few intermediate forms), were lastly joined together.
The offspring were glabrous or intermediate in character, but as they became adult the latter forms lost all their hairs.

The experiments quoted are some made by Miss E. R. Saunders, of Newnham College, Cambridge.

*So-called Species sometimes Wild Hybrids.*—The fact that a number of so-called species occurring in nature have been reproduced by the crossing of other wild species was considered by Mr. Rolfe as of interest to systematic botanists, who must now recognise wild hybrids and the work of hybridists.

*So-called Species which are Garden Hybrids.*—During the discussion Mr. Burbidge showed what great confusion had arisen through the giving of Latin names to garden hybrids of whose origin no record had been kept. Matters would not be improved, one would fancy, through the practice of some nurserymen whom Dr. Masters alluded to in his address, and who, in the earlier days of hybridisation, imagined a foreign locality for their own productions in order to overcome the prejudice then prevalent against hybrids. Mr. Burbidge's suggestion was to give no classical names to hybrids; but if perforce the habit must be continued, let such parts of the parents' names be conjoined as would indicate the origin of the new form. In his paper M. Lemoine traces the previously obscure origin of a lilac by hybridisation experiments; while M. Henry suggests that the conference should undertake similar work, and mentions a number of plants to begin with whose garden history requires elucidation.

## II. THE LIMITS OF HYBRIDISATION AND CROSS-BREEDING.

*In general.*—Mr. Hurst gave statistics showing that up to date twenty-seven genera of Orchideæ, several belonging to different tribes as arranged by the systematic botanists, had been connected together by hybridisation. In other families so much has not been accomplished, but the same speaker noted five species of *Rhododendron* and four of *Gladiolus* that had been linked together. He said that the breeder might reasonably expect to be successful within the limits of a tribe; while, on the other hand, it was urged during the conference that an experiment is easy, and it is better to make it than to argue its non-success instead.

Dr. Wilson, in speaking of his results, said that he had hybrids of *Albuca*, in whose bodies five, if not more, original species were combined.

It can easily be seen that differences in structure may prove insurmountable barriers to hybridisation, but constitutional differences may often be disregarded. For instance, to quote Mr. Hurst, annuals can be crossed with perennials [M. de Vilmorin's poppies], deciduous trees with evergreens [Mr. Herbert Webber's oranges], plants from the tropics with plants from within the Arctic circle.

*Special Cases.*—Prof. Henslow discussed the question of some allied species which unaccountably will not cross, and he smilingly pointed out how much trouble would be saved if only one could tell plants' capabilities in the way of hybridisation from their outside appearance. Sometimes, he said, species of the same genus from different climates and habitats formed no hybrids, while even within the limits of a single species the red "geraniums" (*Pelargonium*) of France would not cross with English races; and certain strains of *Primula sinensis*, also mentioned by Mr. Hurst, and raised by Messrs. Sutton and Sons, were not fertile *inter se*.

*Non-reciprocity.*—Though many reciprocal crosses were recorded in the course of the conference, many failures, it was pointed out by the last-mentioned speaker, are known, but no further light was thrown upon the matter.

## III. CROSSING A MATTER OF CONDITIONS.

Some one alluded to the fact that, whereas it might be found impossible to effect a cross with the earlier produced flowers of an inflorescence, say, yet hybrids could be easily obtained from the blossoms that opened later. In connection with this, Dr. Wilson's hybrid *Passiflora* might be mentioned, where the first flowers to appear contained coronal rays, or else a second and miniature ovary within the walls of the usual one; but in the case of the flowers borne near the ends of branches the pistils were normal. The way in which it was again and again reported that a hybridising experiment had failed for one, two, three, up to seven years shows that successful crossing must depend in a great measure upon at present unknown conditions of nutrition, acclimatisation, temperature, or something else.

## IV. PREPOTENCY AND THE CHARACTER OF HYBRIDS.

*Non-prepotency of Sex.*—Where a hybrid appears to take after one parent in the more obvious and striking parts of its organisation it may resemble the other in more hidden but not less important characters (Mr. Hurst and M. Mael). Again, when species A, on being crossed with species B, produces hybrids that are practically replicas of itself ("false hybrids" of Millardet), it does not follow that the prepotent species, A, must necessarily be male or necessarily female (Henslow). Furthermore, reciprocal hybrids may be identical.

[1] For a *seriatim* account of the papers, see the *Gardeners' Chronicle*, series 3, xxvi. Nos. 655 and 656 (July 15 and 22).

*Partial Prepotency.*—This not very happy title is given by Mr. Hurst to a law which he puts forward as explaining, at least so far as the genus *Paphiopedilum* (= *Cypripedium*) goes, the varied results in the inheritance of characteristics. The law one takes to mean that in one part of an individual hybrid the mother, say, is seen to be prepotent; in another individual the same structure is inherited from the father: while in a third both parents are represented by an intermediate form of the special feature under consideration. We are then asked to imagine a real case where the combinations and permutations of all the component structures must be reckoned with. No doubt this brings the possibilities for variation very forcibly before us; but surely it is only giving another name to what must be expected whenever two parents representing two strains produce young. Although Prof. Ewart's zebra hybrids were mentioned by Mr. Hurst in another connection, yet little heed was given by any one to the possibilities of hybrid plants throwing back to ancestors in the dim past, as undoubtedly appears to be the case with animals.

*Prepotency of Varieties, Species, and Genera.*—Mr. Hurst's paper, which, indeed, was the only one that in any way systematically attacked the broad headings of hybridisation, contained much information deduced from the Orchideæ as to the inheritance by hybrids of the characters which are commonly valued as varietal, specific and generic. As might be imagined, the generic are most difficult to efface; the specific again are less lasting but more persistent than varietal, which are fleeting. Mr. Hurst had, however, to allow that distinct variations may transmit their qualities, and it would be difficult for him to do otherwise in the face of Mr. Bateson's examples; he gave exceptions, which he said are by no means rare—these come in when the variations are slight or the ancestry variable, and an abnormality he found to be transmitted either wholly or not at all. The case given by Prof. Hugo de Vries of the twisted variety of teasel (*Dipsacus sylvestris*) when crossed with *Dipsacus fullonum* being prepotent as regards the abnormality, exemplifies the former of these two alternatives. Prof. de Vries, it should be called to mind, explains it as a case of pangenetic infection. Finally, Mr. Hurst said that when the same variations are found in both strains, they may be traced in the second or following generations, but seldom otherwise. Prof. Vries' second experiment is at first opposed to this; but the latter stage confirms it. He desired to obtain artificially a hairless variety of *Lychnis diurna*, similar to one found in nature, and known as *L. presli*. To do this he crossed the ordinary hirsute variety with his glabrous form of *L. vespertina* already mentioned, and the hybrids were all uniformly hairy. The offspring of these again showed the characters of one or both parents in all degrees. Taking two glabrous examples and crossing them, a constant variety of *L. diurna* without hairs was forthwith obtained, starting with a batch of 390 plants, all glabrous.

*Parthenogenesis and Polyembryony.*—Prof. Henslow, among the many interesting details which he contributed, mentioned how pollen tubes are sent out even when the pollen of a pea is placed upon the stigma of a lily, and how on more nearly allied forms, although no fertilisation may take place, yet the irritation is enough to cause the empty ovary to swell and appear to contain seeds in a way comparable to the formation of galls (partial hybridisation). To explain cases where in crossing a species of one Orchid genus with others, *e.g. Epidendrum* with *Cattleya*, *Laelia* and *Sophronites*, the first was completely prepotent, Mr. Hurst advanced the theory that the occurrence was due to a kind of parthenogenesis, the pollen encouraging the egg-cells to develop into seeds without absolutely having the power to fertilise them.

A difficulty met with in the raising of hybrid races of oranges, which Mr. Webber described, is due to the fact that in the genus *Citrus*, adventitious embryos arise from the cells of the nucellus outside the embryo sac containing the normal egg. The result is that the latter only is affected by pollen, and from the seed arise several seedlings as shown in lantern pictures, only one of which can be the hybrid, the others reproducing the mother plant exactly.

*Vigour.*—The exceptional growth of hybrid plants being a well-known phenomenon was referred to again and again, and was put down by Mr. Hurst to the effect of out-crossing, as in-breeding he found in his experiments reduced the vigour at once.

*Diminution of Fertility.*—Dr. Wilson's results point to this being due to the poor development of pollen, and the lessened fertility of the male was shown by Mr. Hurst's statistics for *Paphiopedilum*. Of crosses in this genus between pure species 95·05 were successful: hybrids fertilised with pollen from pure species produced seeds in 91·82 per cent. of the cases; while pure species were only fertilised by the pollen from hybrids in 60 per cent. of the experiments. The case of male elephants being usually sterile in captivity seems worthy of mention in this connection. Mr. Hurst's generalisation that diminution of fertility is due to conditions of life rather than to any difference in the form or constitution of hybrids gains support, which is added to by the evidence given above under the headings II. (*Special cases*) and III.

*Microscopic Structure.*—Allusion was made to Dr. Macfarlane's work on the structure of primary hybrids, but what little was said about the microscopic conformation of secondary hybrids in *Albuca* (Dr. Wilson), and in *Rhododendron* (Prof. Henslow in the discussion), points to their possessing no internal characters of the importance of specific ones.

*Hybrid Races.*—That secondary hybrids differ more than primary ones from the parent species was the opinion of M. de la Devansaye and Mr. Hurst, and the latter speaker gave a series of figures showing the stability of the former kind; for out of 500 seedlings of a hybrid *Berberis*, 90 per cent. reproduced the immediate parent form, while in no instance was there complete reversion to either of the grandparent species. It is possible that many of our so-called wild species are stable hybrid races.

### V. THE ECONOMIC SIDE OF HYBRIDISATION.

Mr. Webber, in his remarks, and Prof. Bailey, in his paper, both told the same tale with regard to the United States. The bulk of the hybridisation on the other side of the Atlantic is carried on with a view to producing plants that will stand the particularly disadvantageous conditions of frost and drought, and so on, that occur in the wide tracts of land that must be cultivated, or to improving the yield or quality of special vegetable productions upon which many persons depend for their living. Ornamental hybrids are bought for the most part in Europe. The Government does a great part of the work of production, and the experiment stations carry out the work of testing new varieties, be they privately raised or otherwise, which at the same time allows the growers to see the value of the plants before they are distributed. Mr. Hays, in the discussion with regard to the little benefit accruing in this country to the raiser of a new plant, pointed out the opportunity given in America by the system just described for the said plant to be taken up. The Rev. G. H. Engleheart, as an amateur, and Mr. George Paul, as a nurseryman, talked of legislation whereby some sort of copyright should be established in new varieties. Mr. Bunyard pointed out objections, and showed how a man might raise sufficient stock before parting with any to ensure a profit he had calculated beforehand. This presupposes a fairly large sale, and might not be possible to the grower in a small way of business. Mr. Engleheart also alluded to there being no book in which the scattered facts so useful to the hybridist had been brought together.

Perhaps the time will come when there may be State authorities in this country to consider the scientific side of horticulture (as well as entomology and fisheries) in a modern way. At present the annual examination of the Royal Horticultural Society, upon the results of which certificates are granted, includes a theoretical test not only on the practical but on the scientific side. This certificate is the only recognised one which the gardener can obtain, and its value would be much enhanced if the examination were accompanied, or say followed, in the case of candidates who obtain a sufficient number of marks, by a practical examination in both branches of the subject

WILFRED MARK WEBB.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

MR. W. A. HOUSTON, has been appointed to the post of assistant lecturer in mathematics in University College, Liverpool.

THE Agriculture and Technical Instruction (Ireland) Bill was read a third time in the House of Commons on Monday, and a first time in the House of Lords on Tuesday.

THE *University College School Magazine* announces that Mr. R. Tucker, who has guided the mathematical fortunes of the

school since 1865 with great success, will retire from his post at the close of this session.

DR. W. SOMERVILLE, professor of agriculture and forestry at the College of Science, Newcastle-upon-Tyne, in connection with the University of Durham, has been elected to the new professorship of agriculture in Cambridge University.

PARTICULARS concerning British, Continental and Canadian Universities, with special reference to institutions having courses open to women, are given in a "Handbook" compiled by Dr. Isabel Maddison for the Graduate Club of Bryn Mawr College, and published by the Macmillan Company, New York. We notice that Queen's College, London, which celebrated its jubilee last year, has been omitted. As the volume is primarily intended to indicate colleges for women students, the omission of a college of this kind possessing a Royal Charter is unfortunate.

THE departmental committee appointed by the Lord President of the Council to consider the question of the reorganisation of the Education and Science and Art Departments consists of Sir Horace Walpole, K.C.B (chairman), Sir G W. Kekewich, K.C.B., Secretary of the Education and Science and Art Departments, Captain W. de W. Abney, C.B., principal assistant-secretary of the Science and Art Department, Mr. S. Spring Rice, C.B., of the Treasury, and Mr. W. Tucker, C.B., principal assistant-secretary of the Education Department.

THE ninth summer meeting of University Extension Students will be opened at Oxford on July 29. Many prominent members of the University have arranged to take part in the meeting. In the scientific section Prof. Gotch will deal with "The Physiology of Sensation," Prof. Sollas will lecture on "The Geology of Oxford," Prof. H. A. Miers on "The Growth of a Crystal," Mr. H. N. Dickson, New College, on "The Influence of Climate," Mr. G. C. Bourne, University lecturer in Anatomy, on "The Growth of the Living Organism," Mr. G. J. Burch on "Wireless Telegraphy," and Dr. Arthur Ransome on "Microbes and Disease."

MR. A. F. STANLEY KENT has been appointed professor of physiology in University College, Bristol. Mr. Kent received his scientific training at Oxford, which he left upon being appointed demonstrator of physiology in Owens College, Manchester. In 1889 he was invited by Sir J. S. Burdon-Sanderson to take charge of the histological department at Oxford, to lecture on special points in physiology, and to assist in the teaching of general physiology. Since 1892 he has been assistant lecturer in physiology and histology at St. Thomas's Hospital, and has carried out a number of researches, the results of which have been published in various journals, proceedings, and reports.

SECONDARY as well as elementary schools are now beginning to appreciate the advantage of having upon their staff one or more teachers who thoroughly understand the application of the theory and practice of hygiene in school life; and the desirability of emphasising the necessity of this knowledge in the code for elementary schools is now being pressed upon the Education Department by memorials from several important bodies. To encourage the systematic study of the subject, the Council of the Sanitary Institute have decided to arrange a thorough theoretical and practical examination, which will be open to both classes of teachers and to those preparing as teachers. The first examinations will be held during February and June next year.

THE first of a series of articles dealing with the provision made by local authorities for the technical education of miners appears in the July number of the *Record* of Technical and Secondary Education, the information given having reference to the County Councils of Cornwall, Durham, Northumberland, and the West Riding of Yorkshire. The permanent schools of mining in Cornwall are at Camborne and Redruth, in the centre of the Cornish mining district, and they thus afford exceptional facilities for the acquisition of a practical as well as a theoretical knowledge of mining and its allied subjects. As regards the provision of practical work other than that concerned with elementary scientific principles, the Committee of the Redruth School have made arrangements with the managers of neighbouring mines for the practical instruction of the students. The Committee of the Camborne School adopt the same system to some extent, but are also themselves the owner of a portion of a mine, having purchased the same in 1897 for the use of students. Cornwall thus furnishes a unique instance of educational procedure by reason of this purchase of a mine by a local school committee.

As the result of a conference between representatives of the London School Board and London County Council, having for its object the prevention of overlapping of classes, the representatives of the former body have resolved to recommend the Board to adopt the following proposals among others:—(1) The School Board will limit its instruction in science and art in all its evening schools to such grades as can be conveniently taught in its premises, and will look to the Technical Education Board to give the advanced instruction in the premises under their control. (2) The School Board will not conduct classes in technological subjects, and will not offer instruction specially intended for university degrees. (3) The School Board proposes to conduct preparatory classes in elementary experimental science, in elementary freehand, geometrical, and model drawing, and in the drawing of simple pieces of mechanism; in mensuration and workshop arithmetic, and in algebra, to enable pupils to understand the meaning of an algebraical formula. (4) The School Board proposes to conduct evening classes in manual training, woodwork, and metal-work as part of a general education, and as preparatory to commercial workshops, but to refer students who are members of specific trades, and require trade teaching, to the Polytechnics and Technical Institutes.

## *SCIENTIFIC SERIALS.*

*Symons's Monthly Meteorological Magazine*, July.—Meteorological extremes: Pressure. Mr. Symons has undertaken to give, in alternate numbers, a list of extremes of the various meteorological elements. The task is by no means easy, as the information is scattered, in many books and languages, and some of the statements will no doubt lead to useful criticisms. The highest recorded barometric pressures (reduced and corrected) are 31·78 inches at Irkutsk, January 14, 1893; 31·72 inches at Semipalatinsk, December 16, 1877; and 31·62 inches at Barnaul, December 14, 1877. Dr. Woeikof doubts the accuracy of the first reading, *inter alia*, because the temperature for reducing *up* to the freezing point had been taken at $-51°·34$ F., and had been assumed to prevail from Irkutsk to the sea. He maintains that the reading of 31·62 inches at Barnaul is really the best established barometrical maximum as yet on record. The reduction to sea-level from stations some thousands of miles from the nearest sea renders the statements more doubtful than readings taken near the sea-shore. The highest readings in the British Isles are 31·108 inches at Ochtertyre, and 31·106 inches at Fort William, both on January 9, 1896. The highest reading in the neighbourhood of London since 1858 (the date of commencing observations at Camden Square) is 30·934, January 9, 1896. The lowest pressures are those referred to in NATURE, vol. xxxv. p. 344, viz. 27·135 on September 22, 1885, at False Point on the coast of Orissa. In the *Quarterly Journal* of the Royal Meteorological Society, vol. xiii. p. 212, Mr. C. Harding pointed out that for comparison with English standards a further subtractive correction of ·011 inch has to be applied, which would make the lowest reading 27·124 inches. The next lowest reading occurred at Ochtertyre on January 26, 1884, viz. 27·332 inches. The lowest reading at Camden Square is 28·295, December 9, 1896.

*Bulletin of the American Mathematical Society*, July.—The asymptotic lines of the Kummer surface, by Dr. J. I. Hutchinson, was read at the April meeting. These curves have been discussed by Klein and Lie, Reye, Segre and Rohn from the point of view of line geometry. This notelet gives a simple solution by making use of the parametric representation of the Kummer surface in terms of hyperelliptic functions.—On a definitive property of the covariant, by C. J. Keyser, was read at the same meeting. The writer refers to three proofs, due to Jordan, Elliott and Fiske respectively.—Yet another paper read at this meeting was the known finite simple groups, by Prof. L. E. Dickson. This is in part a *résumé* of previous work done by the author, and gives a table which should aid in the determination of the status of a newly-discovered simple group.—Reviews follow, viz. of Schoenflies' "Geometrie der Bewegung in Synthetischer Darstellung," and of Speckel's "La Géométrie du Mouvement Exposé: Synthétique," by Prof. F. Morley; a short notice of the second edition of the second volume of Weber's "Lehrbuch der Algebra," by Prof. Pierpont. Shorter notices

are Teixeira's "Corso de Analyse infinitesimal: Rudio's Verhandlungen der ersten internationalen Mathematiker-Kongresses in Zürich," vom 9 bis 11 August, 1897; Klein's lectures on the mathematical theory of the top; Moritz Cantor's "Politische Arithmetik oder die Arithmetik der taglichen Lebens"; and Virgilii and Garibaldi's "Introduzione alla Economia Matematica."—Prof. J. Pierpont gives a short note on elliptic functions, which discusses the simplest and most natural way of presenting the theory.—Notes, new publications as usual, and the index follow.

## *SOCIETIES AND ACADEMIES.*

### LONDON.

Royal Society, June 15.—"A Preliminary Note on the Morphology and Distribution of the Organism found in the Tsetse Fly Disease." By H. G. Plimmer and J. Rose Bradford, F.R.S., Professor Superintendent of the Brown Institution. (From the Laboratory of the Brown Institution.)

These observations are the result of an inquiry entrusted to us by the Tsetse Fly Committee of the Royal Society, at a meeting of the Committee on March 16, 1899.

The material for our investigations was obtained in the first place from a dog and a rat, inoculated with the blood of a dog suffering from the disease, by Mr. H. E. Durham, at Cambridge.

The organism found in the Tsetse Fly disease was discovered by Major Bruce, R.A.M.C., F.R.S., and was classed by him as a Trypanosoma. These belong to the order Flagellata, and, according to Bütschli, to the sub-group Monadina.

We will, in the first place, describe the adult form of the organism, such as is met with most frequently in the blood of a susceptible animal affected with the disease.

A. *Description of the Adult Form of the Trypanosoma.*

In freshly drawn blood examined as a hanging drop, or as a very thin layer in a cell, the adult form of the Trypanosoma can be easily studied. The latter method is the better, as the organism can be better seen and more accurately examined, in the thin, uniform layer of fluid than in the rounded drop. The easiest method of examining the blood in this way is to make, with a red-hot platinum loop and a small piece of paraffin, a thin ring of paraffin on an ordinary glass slide; the drop of blood is placed in the centre of the ring and a cover-glass placed on it, the thin layer of paraffin preventing pressure. If it be desired to keep the blood for continuous examination, it should be drawn into a graduated Pasteur pipette, and one-tenth part of a 5 per cent. solution of sodium citrate should be drawn up after it, then the blood and citrate solution should be carefully mixed in the bulb; the tube should then be sealed up, and drops can be taken from it as desired.

Under ordinary conditions of illumination the Trypanosoma, as seen in the blood, appears to consist of a uniform, homogeneous mass of protoplasm, of worm-like form, with at one end a thick, stiff extremity, and at the other a long, wavy flagellum. It is generally in active motion, and this is seen to be caused by the rapid lashing movement of the flagellum, and by the rapid contractions and relaxations of the mass of protoplasm forming the body, and by the movements of an undulating membrane which is attached to one surface of the body, and which appears to undulate synchronously with the contractions of the protoplasmic body. This membrane is, excepting at the free edge, very transparent, and can be seen much better in citrated blood which has been thickened by the addition of a small drop of 1 per cent. gelatine solution, when its contour and attachments can be much better made out, owing to the slower rate of vibration effected by the thickened medium.

The general shape of the Trypanosoma, when rendered quiescent by this means, but not killed, is that of a long oval, with one end blunt and the other continued into the flagellum; the membrane is then seen to be attached to one side of the body; it begins a little in front of the blunt end of the organism, and is continued at the end into the flagellum.

But with better illumination, such as a very oblique pencil of rays, or, better still, with monochromatic light (green or blue), the protoplasm is seen not to be homogeneous. The organism appears then as a highly refractive body, and near the middle, or between it and the flagellate end, is seen a large dark body much more refractive than the rest of the protoplasm; this is the macronucleus. Near the thick, stiff end of the body a tiny still more refractive body (with monochromatic light nearly black) is seen, which is the micronucleus. The addition of a drop of 5 per cent. acetic acid makes both of these bodies much more distinct. At the stiff end of the Trypanosoma, in varying relation to the micronucleus, is seen a vacuole. There is no suggestion of a mouth or of any organs, but the protoplasm with the most careful illumination appears not to be uniform, which suggests an alveolar structure, as described by Bütschli. With the ordinary simple stains (hæmatoxylin, fuchsin, methylene-blue, thionin) the differentiation is not much better than can be observed by careful illumination of living unstained organisms, as these stains are with these, and similar organisms, too diffuse to be of any service. Acting on a method which Ehrlich originated in 1889, and which Romanowsky modified in 1891, and which has still been further elaborated by Ziemann in 1898, we have used a mixture of methylene-blue and erythrosin, which has enabled us to follow the different stages of the Trypanosoma with certainty. This method depends on the fact that when a basic and an acid stain are mixed together in certain proportions, a third neutral body is formed, which has a specific colour reaction with chromatin. By the use of this method we have been able to trace the various stages of the organism in the blood and organs of the affected animals, which is not possible with the ordinary stains, these being useless for many of the forms to be presently described. With this method the macronucleus of the Trypanosoma is stained a clear, transparent, crimson lake, the micronucleus a deep red, and the protoplasm a delicate blue; these reactions are constant throughout all the stages of its life-history.

The protoplasm of the adult Trypanosoma does not stain uniformly, as does that of some of the other forms, but there are parts faintly stained and parts unstained, which is again in favour of the alveolar structure mentioned above. The vacuole is quite distinct as a clear round space when the organism is stained by this method.

The macronucleus is generally of an oval or elongated shape, and it may be either uniform in colour, or in the form of fine threads; this latter is seen especially in those forms which show other signs of division. The micronucleus is seen as an intensely stained round dot, or as a short rod, this latter form again being seen in those forms which show other signs of approaching division. With the highest powers (1·5 apochromatic objective and 18 compensating eyepiece of Zeiss) we have not been able to make out any special structural characters in this body. The flagellum is not stained by this method, but if the preparation has been well fixed, it is easily visible; the vibratile membrane also is unstained, and can be generally better studied in specimens stained by simple stains, preferably thionin.

As regards the movements of the organism, in preparations where no pressure is exercised, they can be seen moving either with the flagellum or with the blunt end in front; but we think that the commoner mode of progression is with the flagellum forward.

The size and length of the body varies very much with the period of the disease at which the blood is examined and with the kind of animal. The largest forms we have seen have been in rats' blood, just after death, and the smallest in rabbits' blood, early in the disease.

B. *Distribution of the Trypanosoma.*

(1) *In the Body of Normal Animals.*

(*a*) *In the Blood.*—We have found the flagellate form in the greatest numbers in the blood of the mouse, towards the end of the disease. In the rat also they occur in great numbers, and in both these animals they can be found in the blood on the fourth or fifth day. In the dog large numbers can be seen in the blood from the sixth day. In the cat they are fewer in number in the same lapse of time than in any of the animals before mentioned.

The rabbit seems to be the most refractory animal of any we have as yet used, and the Trypanosoma are found in the blood in small numbers only, and at very uncertain intervals.

(*b*) *In the Lymphatic Glands.*—In the superficial glands nearest to the point of inoculation the flagellate organism can be found earliest. In the rat the Trypanosoma can be found in the nearest superficial gland in twenty-four hours after inoculation. We have not found that generalisation of the organism in the lymphatic glands occurs until nearly the end of the disease, when the organism is present in very large numbers

in the blood. In the rabbit, in which the organisms are few or rare in the blood, the glands do not show any marked change, and the Trypanosoma are not readily found in them. Many other forms are found in the glands, to which reference will be made below.

(*c*) *In the Spleen.*—The adult Trypanosoma is found in but small numbers in the spleens of the various animals we have examined; but other forms are found there which will be described later. The enlargement of the spleen is *post mortem* the most obvious fact in the morbid anatomy of the disease; it may attain even to four or five times the average volume—this is especially the case in the rat.

(*d*) *In the Bone-marrow.*—We have found either very few flagellate organisms, or none at all, in the bone-marrow of the various animals we have worked with. The marrow is altered in colour and structure, but there does not seem to be a greater number of Trypanosoma than can be accounted for by the blood in the marrow.

In the other organs and parts, the number of organisms present depends upon the relative quantity of blood in the part.

(2) *In the Body of Spleenless Animals.*—As the spleen in the ordinary animals is the organ which is most obviously altered in this disease, we have made a series of inoculations into animals (dog, cat, and rabbit) from which the spleen had been removed a year ago. In the dog, the adult forms of the Trypanosoma are not found so early in the blood of spleenless as in that of ordinary animals (seventh day as compared with fourth day after inoculation). The glands, after death, are much more generally enlarged, and are reddish in colour, and contain many more organisms than in the normal animal. Both the blood and glands contain, however, numerous other forms to be described below.

This marked difference in the colour of the glands of spleenless animals is probably due to the removal of the spleen, and the glands consequently taking on some of the splenic functions.

The bone-marrow is much altered, and in it likewise are found a large number of Trypanosoma, both flagellate and what are termed below "amœboid" forms.

In the cat the conditions of experiment were altered, the blood (1 c.c.) from the infected animal being introduced, with every precaution to avoid contamination of the tissues, direct into the jugular vein. In this case the organism appeared in the blood in numbers on the fourth day, and the animal died on the twelfth day. As the Trypanosoma were introduced into the blood stream direct, there was no marked glandular enlargement, but the glands were all reddish in colour, the change in colour being due to the spleenectomy. A few adult organisms were found in the glands and in the bone-marrow.

In the spleenless rabbit a few Trypanosoma have been found in the blood on two occasions, but the animal lived nearly two months, and notwithstanding the failure to detect adult flagellate forms in the blood on numerous occasions, the blood was always infective, and contained numerous forms termed "amœboid" and "plasmodial" below.

### C. *Infectivity.*

(*a*) *In Ordinary Animals.*—The blood and organs of an animal dead of the disease lose, before twenty-four hours after death, their infective power. This is apparently due to the rapidity with which decomposition sets in after death, as we have found living Trypanosoma in film preparations, made as described above, as long as five to six days after removal of the blood from the body; and we have also found that large quantities (200 c.c.) of blood removed from the body into a sterile vessel and kept in an atmosphere of oxygen, retain their virulence for at least three days, notwithstanding the fact that the flagellate form cannot be demonstrated.

We have found that the blood of the dog is infective at least two days before any adult Trypanosoma can be seen in the blood; and we have also found that the blood of the spleenless rabbit, in which we have only on two occasions seen any adult forms, is invariably infective. This, of course, suggests the idea that the organisms must be present in another form, and we have been able, by the use of the method of staining described above, to demonstrate the presence of other forms in the blood and organs, and have shown, by the experiments just mentioned, that the infectivity of the blood, in cases where there are no flagellate forms discoverable, depends in all probability upon the presence of one of the other forms which the Trypanosoma assumes.

Although a differential staining method, such as the one we have used, is necessary for following and demonstrating the various stages of the life-history of the Trypanosoma, still these stages can be seen in unstained living specimens, with very careful illumination. As a matter of fact, our first observation of them was in unstained preparations.

In the blood of the dog, cat, rabbit, rat, and mouse, besides the adult forms as described above, which, as mentioned, are very various in size, there are adult forms undergoing division, both longitudinal and transverse, to which reference will be made later. Also two organisms are sometimes seen with their micronuclei in close apposition, or fused together, with more or less of their bodies also merged together. Such forms we believe are conjugations. Again, there are other large forms, with or without a flagellum, in which the chromatin of the macronucleus is broken up into a number of tiny granules, not bigger often than the micronucleus. Besides these there are other forms, which we call for convenience here "amœboid" forms, by which term we mean single, small, irregularly shaped forms, with or without a flagellum, but always with a macro- and micro-nucleus. These nuclear structures are generally surrounded by a very delicate envelope of protoplasm, of greater or lesser extent, but occasionally forms are seen which seem to consist only of chromatin, with or without a flagellum. Besides these, again, there are other forms which we call, also for convenience, "plasmodial" forms, meaning thereby an aggregation or fusion of two or more amœboid forms. In the blood these plasmodia are not generally very large, but may show evidence of from two to eight separate elements. Signs of division are very common; but in the blood one does not often meet with a plasmodium dividing up into more than four organisms of the adult shape. The plasmodial form also retains intact the two nuclear structures—the macro- and micro-nucleus—which we believe divide in the plasmodium, thus increasing its size.

In the spleenless animals the blood may contain no forms but the amœboid and plasmodial, such as is the case in the rabbit, yet this blood is infective; moreover, in the dog, before the adult organism appears in it, the blood is infective, and therein, at this period, these plasmodial forms can be demonstrated. In the glands these plasmodial forms are found, but only in quantity in those animals from which the spleen has been removed.

The spleen is the organ which shows these forms in the greatest abundance. The whole spleen is crammed in every part with plasmodia, which are wedged in between the splenic cells in every direction: many amœboid forms and also immature flagellate forms are also seen, but the most striking thing is the enormous quantity and uniform distribution of the plasmodia. The great enlargement of the spleen, which we have found constant in all the animals we have used, is caused by this mass of plasmodia, which we have found in the spleen within forty-eight hours from the time of inoculation.

In the marrow these plasmodial forms are only found, so far as our experience goes, in those animals from which the spleen has been removed. In these cases there are both plasmodial and amœboid forms in the marrow, the latter the more abundant.

The principal differences in the distribution of the plasmodial forms in animals with and without spleens is this: that in the animals with spleens the organ of choice for the plasmodia is the spleen, but they are also found constantly in the blood, and in less quantity in the glands, whereas in animals from which the spleen has been removed the plasmodial forms are plentiful in the blood, the glands, and the bone-marrow.

### D. *Life-History of the* Trypanosoma "Brucii."

Besides the forms mentioned above, we have seen in the blood and in the organs divisions of the adult form, both longitudinal and transverse, the former the more frequent; but we think that this direct mode of reproduction is far less common than the indirect by means of conjugation (probably), breaking up of chromatin, production of amœboid forms, with subsequent division of these amœboid forms, and the formation of plasmodia by the aggregation or fusion of the amœboid forms, and these finally giving off flagellate forms, at first small, and gradually increasing up to the normal adult form.

So that we should tentatively summarise the life-history of the Trypanosoma found in Tsetse Fly disease, which we think might properly be called "*Trypanosoma Brucii*," in recognition

of the work done in connection with it by its discoverer Major Bruce, F.R.S., as follows:—

(1) Reproduction by division, this being of two kinds:—

(*a*) Longitudinal, the commoner.
(*b*) Transverse, less frequent.

(2) Conjugation, consisting essentially, so far as our observations go, of fusion of the micro-nuclei of the conjugating organisms.

(*a*) After this we are inclined to place those forms mentioned above, in which the chromatin is broken up, and scattered more or less uniformly through the whole body of the Trypanosoma, since this occurs after conjugation in other organisms not far removed biologically from this one. The next stage in our opinion is the amœboid; we think that the flagellate form becomes amœboid perhaps after conjugation, but also probably apart from this process.

(*b*) Amœboid forms. These are found with and without flagella, of various shapes and sizes, but always possessing a macro- and micro-nucleus. These forms are constantly seen in the process of division, and sometimes are very irregular in shape, with, in this case, an unequal number of macro- and micro-nuclei, the latter being the more abundant. The amœboid forms then fuse, or aggregate, together to form—

(*c*) The plasmodial forms. Whether these are true plasmodia, or whether they are only aggregations of amœboid forms, it is not yet possible to say, but as many related organisms form true plasmodia we are inclined to look upon these masses, provisionally, as true plasmodia. In the spleen these plasmodia reach a large size. From these again are given off—

(*d*) Flagellate forms, which increase in size, and become the ordinary adult form. Small flagellate forms are not infrequently seen in process of separation from the margin of these plasmodial masses.

Besides these forms we have observed frequently, especially in rat's blood after death, the adult forms arranged in clumps. They appear, upon watching them for a considerable time, to get tangled together to form a large writhing mass; then the movements become gradually slower in the centre of the mass, and are only seen at the periphery. At this stage, if the specimen be fixed, the mass appears to be made up of a quantity of macro- and micro-nuclei, as the protoplasm does not stain, except in the organisms at the periphery, *i.e.* those which have arrived latest. Eventually these, too, become motionless, and the mass becomes an indistinct collection of granular matter, which is not infective, so that we look upon these tangles as a proof of death.

Since these observations were made, there has been published an important paper on the Rat Trypanosoma, by Lydia Rabinowitch and Walter Kempner in the *Zeitschrift für Hygiene*, vol. xxx. part 2. We have been able to confirm many of the observations and statements as to the morphology and reproduction of the Trypanosoma made by these writers. But there is no mention made of the plasmodial stage, or of any reproductive stage elsewhere than in the blood; and the writers recognise only three methods of reproduction, namely, longitudinal and transverse division, and division by segmentation. This segmentation, they consider, arises from *one* organism, and they state that it may divide up into as many as ten to sixteen elements. This segmentation form would seem to correspond to our plasmodial stage, but we have seen much larger masses than those mentioned above, and they do not notice the enormous masses of plasmodia which infiltrate the spleen in every direction, and which can be found also in glands and marrow. Moreover, their amœboid stage (Kugelform) would precede the segmentation form, and therefore the "Kugelform" should be much larger than the ordinary adult form, but we have observed that, as a rule, our amœboid forms are very much smaller than the adult forms, some not being visible with any but the highest magnifying powers; so that we have been unable to accept this form of division by segmentation, except in the form in which we have described it above, *i.e.* our plasmodial stage.

EDINBURGH.

Royal Society, July 3.—Prof. Copeland in the chair.—A telegram from Lord Kelvin was read on magnetism and molecular rotation. An electrified body is set into rotation by the generation of a magnetic field around it. The magneto-optic phenomena discovered by Faraday, Kerr, and Zeeman are to be thus explained.—Prof. Tait communicated a paper by Prof. C. N. Little on the non-alternate ± knots of the tenth order. The characteristic of non-alternate knots is that, as we pass round it, the crossings do not always come alternately above and below. The simplest non-alternate knot is one of eight crossings; and Prof. Little has now carried the census of these knots as far as the tenth order.—Prof. Sir W. Turner read a paper on contributions to the craniology of the people of the Empire of India: Part I. "The Hill Tribes of the North-east Frontier and the People of Burmah." Certain of the skulls which were shown, and discussed in detail, came from the Lushai-Chin region, and were, with few exceptions, of the dolichocephalic type. Yet the features of these people are distinctly Mongolian; and the typical Mongolian skull is brachycephalic. The same peculiarity was shown in eight skulls which Surgeon Lieut.-Colonel Wright had sent from the Naga Hills north of Manipur—the skull being dolichocephalic but the features Mongolian, and therefore usually belonging to the brachycephalic type. On the other hand, the Burmese skulls, which had been supplied by Surgeon Captain Bannerman and Surgeon Major Bell, were, with two exceptions, brachycephalic.—Sir William Turner also read a paper on decorated and sculptured skulls from New Guinea. These had all come from British territory. The sculptured skulls were of special interest, the sculpturing in all cases being executed on the frontal bone. Sir William distinguished five distinct types of sculpturing, and threw out various speculations as to their significance.—Dr. Hepburn described and exhibited an improved form of craniometer for the segmentation of the transverse, vertical, and antero-posterior diameters of the cranium. In this improved form of cranial calliper, the graduated bar has zero at its centre, and the two curved legs of the callipers are both movable, each along its own half of the bar, which is graduated from the centre outwards. At the centre of the bar a straight calliper leg is introduced, being sunk in an undercut groove so that it may be adjusted to any required convenient length. The instrument may be used as an ordinary calliper by removing the centre limb, clamping the one calliper leg, and reading on the reverse side of the bar, which is graduated continuously from end to end. In using the improved form, we place the point of the central limb on any desired spot, and adjust the two curved limbs until they touch the ends of the chord to be measured. The measurements give, not only the length of chord, but also indicate the amount of asymmetry. The instrument had been tested on a number of skulls of various human races and of anthropoid apes. The relative heights of cerebrum and cerebellum had been determined, the position of the occipital condyles in relation to the greatest length had been studied, and a variety of other results obtained. In all such measurements the dolichocephalic skulls came nearer to those of the anthropoid apes than the brachycephalic skulls.—Mr. J. Y. Buchanan read a paper on the meteorology of Ben Nevis in clear and in foggy weather. The days in which the mountain was enveloped in cloud were first separated from the days when a clear atmosphere prevailed, the minimum of foggy weather being taken as three consecutive days, and the minimum of clear weather as twenty-four consecutive hours. As was to be expected, the foggy weather contained all the worst weather, and the clear weather all the best. Also in foggy weather the barometer was, on an average, half an inch lower than in clear weather.

July 10.—Prof. Copeland in the chair.—At the request of the Council, Prof. Cargill G. Knott gave an address on earthquakes, their propagation through the earth, and their bearing on the question of the earth's internal state. A brief sketch of the history of earthquake research was followed by an account, illustrated by lantern slides, of the various forms of seismographs, seismoscopes, seismometers, tromometers, &c., which have been devised, more especially in Italy and Japan, for the recording of the gentler types of earthquakes, and of seismic vibrations too feeble to be perceived by our senses. This led to a discussion of the main characteristic of those minute vibrations which have their origin at an earthquake focus, and pass across thousands of miles to be recorded on suitable instruments at localities not themselves subject to even feeble shocks. The results recently established by Prof. John Milne, F.R.S. (see various letters in last volume of NATURE), were then described, and certain conclusions deduced. The manner in which a far-travelled earthquake disturbance was drawn out in time seemed to be better explained in terms of a

solid than of a fluid earth. Reasons were also given for believing that seismic activity was greater in earlier geologic times than now; and that, if this were so, stratigraphical changes would almost certainly have taken place more quickly in former ages.

PARIS.

Academy of Sciences, July 17.—M. van Tieghem in the chair.—On the combinations of sulphide of carbon with hydrogen and nitrogen, by M. Berthelot. A mixture of hydrogen and carbon bisulphide was submitted to the action of the silent discharge for some hours. The carbon bisulphide was found to have combined with about half its volume of hydrogen. Similar experiments with nitrogen in place of hydrogen showed that combination also took place, the proportions in two experiments being $7CS_2 : N_2$ and $4CS_2 : N_2$.—Remarks on the combination of nitrogen with oxygen, by M. Berthelot. The author's results agree with those obtained by previous workers in the same field.—On the advantages of autumn crops, and their usefulness as a green manure, by M. P. Deherain. A green crop, such as vetch or potato, sown over the wheat stubble immediately after the harvest, is usually successful if the months of August and September are not too dry.—Remarks by M. Lœwy on some lunar photographs presented by M. Weineck.—On some transformations of some right lines, by M. E. O. Lovett.—On the general theory of congruences of circles and spheres, by M. C. Guichard.—On the Mossotti-Clausuis and Betti formulæ relating to the polarisation of dielectrics, by M. F. Beaulard. The author investigates a formula for the dielectric capacity of a mixture of a conductor and a non-conductor, and shows experimentally that for a mixture of copper and paraffin the formulæ of Poisson and of Betti both agree with the results found.—Do rarefied gases possess electrolytic conductivity? by M. E. Bouty. From the experiments quoted the author concludes that the electrical properties of a gas cannot be considered as resembling those of any known electrolyte. For a given pressure of gas there is a certain value for the strength of field below which the rarefied gas acts as a perfect dielectric. As the strength of the field is increased there is produced a sudden change, manifested by the luminescence of the tube.—On the reversible temporary and residual variations in nickel steels, by M. C. E. Guillaume.—On chromic acetate, by M. A. Recoura. Chromium acetate, $Cr(C_2H_3O_2)_3$, has been obtained in four isomeric forms; thus differing from the other chromium salts previously studied, which only give two.—On the prevention and cure of toxic epilepsy by the injection of normal nerve substance, by MM. V. Babes and Bacoucea. Injections of nerve substance were found in some cases to retard or prevent epilepsy artificially induced in rabbits.—On the presence of a soluble reducing ferment in the animal organism. Reducing power of extracts of organs, by MM. E. Abelous and E. Gerard. The kidney of the horse, macerated with chloroform water, gives a ferment capable of reducing potassium and ammonium nitrates to nitrites. It decolorises methylene blue, and appears to give butyric aldehyde with butyric acid. The ferment is destroyed at 72° by mercuric chloride solution, but the activity of reduction is not impaired by the addition of such antiseptics as thymol or sodium fluoride.—On the development of the chicken, by M. Etienne Rabaud.—Tarsian regeneration, and regeneration of the members of the two anterior pairs in the leaping Orthoptera, by M. Edmond Bordage. The loss of the front pair of appendages is usually fatal to the insect, but when it survives, if still in the larval state, regeneration may give a perfect member again. The contradiction to the law of Lessona is only apparent.—Division of the nucleus in the spermatogenesis of man, by M. Sappin-Trouffy. The two modes of division studied yielded multiplication cells with a single nucleus, and polynucleated reduction cells, or mother cells of spermatozoids.—Osseous regeneration, followed with radiography, by M. Abel Buguet.—Radiography of calculus of the kidney, by MM. Albarran and Contremoulin. The exact position of the renal calculi was discovered by radiography previous to removal.—Radiography of the heart and aorta at the different phases of cardiac revolution, by M. H. Guilleminot.—The *rôle* of the locomotor organs in the horse, by M. P. Le Hello.—On the development and pisciculture of the turbot, by M. A. Eugène Malard. The culture of the turbot would appear to be easy provided the basins are of sufficient capacity.—Experimental researches on dreams. On the continuity of dreams during sleep, by M. Vaschide.

AMSTERDAM.

Royal Academy of Sciences, June 24.—Prof. H. G. van de Sande Bakhuyzen in the chair.—Prof. Schoute reported, on behalf of Prof. Cardinaal and himself, on the treatise by Mrs. Alicia Boole Stott, entitled "On certain series of sections of the regular four-dimensional hypersolids" The conclusion of the report, viz. that the treatise should be inserted in the *Transactions* of the Academy, was approved.—Prof. Lobry de Bruyn made, on behalf of both Dr. A. Steger and himself, a communication concerning the influence of water upon the rapidity of the formation of ether from methyl iodide and ethyl iodide, and from sodium methylate and sodium ethylate. This inquiry, which is a sequel to a previous study of the conversion of *o*-dinitrobenzol with sodium methylate and sodium ethylate, showed that the addition of constantly increasing quantities of water did not prevent the occurrence of constant reaction coefficients. In the case of methyl iodide it was possible to continue the inquiry down to pure water; as in the case of the above-mentioned reaction with *o*-dinitrobenzol, water here also proved to cause the reaction coefficient in ethyl alcohol to constantly decrease, while in the case of methyl alcohol it first rose and then also fell. That the sodium, dissolved in aqueous ethyl alcohol of 50 per cent., was for the greater part present as alcoholate, was proved by an experiment the result of which was that ethyl iodide was for the greater part converted into ordinary ether by such a solution.—Prof. Bakhuis Roozeboom made two communications: (*a*) on an instance of conversion of mixture crystals in a compound; (*b*) (on behalf of Dr. Ernst Cohen and Mr. C. van Eyk) on the enantiotropy of tin.—The following papers were presented for publication in the *Proceedings*: (*a*) one by Prof. J. C. Kluyver, on the continuation of a univalent function represented by a doubly infinite series; (*b*) one by Prof. Kamerlingh Onnes, on standard gasmanometers; (*c*) one by Mr. N. Quint (presented by Prof. Van der Waals), on determinations of the isotherms of mixtures of hydrochloric acid and ethane; and one by Prof. Lorentz (also presented by Prof. Van der Waals), on the elementary theory of Zeeman's effect, being a reply to the objections of Prof. Poincaré.—Prof. Mulder presented for publication in the *Transactions* a treatise entitled "On peroxy-silver sulphate and peroxy-silver acetate" (sixth paper).—Prof. H. G. van de Sande Bakhuyzen communicated the fact that the comet the orbit of which was computed a few years ago by Mr. Zwiers in a treatise published by the Academy had appeared again, and that the place observed corresponded very closely with the one computed beforehand.

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THURSDAY, AUGUST 3, 1899.

## NORWEGIAN MARINE INVESTIGATIONS.

*Bergens Museum. Report on Norwegian Marine Investigations*, 1895–97. By Dr. Johan Hjort, O. Nordgaard and H. H. Gran. (Bergen: John Grieg, 1899.)

THIS Report contains two papers, the first, on the "Currents and Pelagic Life in the Northern Ocean," by Drs. Hjort and Gran, and the second, "A Contribution to the Study of Hydrography and Biology on the Coast of Norway," by O. Nordgaard.

In the first paper, the authors give the general results of their observations on the hydrography and pelagic life of the Northern Ocean obtained during recent years. More detailed results of their observations in Norwegian waters, with especial reference to the herring fishery, are reserved for future publication.

It may at once be said that this work, though only an instalment, is a very important contribution to oceanographical knowledge, and well sustains the character of Scandinavian research.

The first chapter deals with the hydrographical condition of the Northern Ocean, and the second chapter contains plankton studies in the same region. Then follow voluminous and detailed tables of the actual observations. These tables are illustrated by a series of seven plates, which show easily and very clearly the peculiarities of the region under description.

The Northern Ocean, as a deep-water basin, lies on the polar side of a curved line passing through Iceland, the Farö Islands, and reaching the Norwegian coast at the point where its trend changes from north to north-east. The shallow water portion includes all the Norwegian littoral waters and the portion of the North Sea between Norway and Scotland lying north of latitude 57° or 58° N. The Wyville Thomson ridge connecting Iceland with the Farös and the Orkney Islands is debatable ground separating the Atlantic from the Arctic areas. The position and the bathymetric characteristics of the different regions are very well shown in Plate I., taken from Mohn's "Northern Ocean."

Along the entire Norwegian seaboard there are three deep regions of well-marked hydrographic characters: (1) The region of periodical changes to a depth of 200 or 250 metres; (2) the Atlantic region to a depth of 500 metres; and (3) the Arctic region. Referring to this classification, the authors say:

"Of these regions it is chiefly the uppermost that is of interest to us, as it is our main purpose to unravel all the conditions which may influence the migration of fishes; and it may well be presumed that the great changes produced by currents, by summer warmth and winter cold, and the variations from year to year of the different factors, may be of the greatest importance to the periodical fisheries."

In pursuing the investigations of these conditions, five sections of the sea off the coast between Stavanger and Lofoten were made in 1895 by Hjort, and the same ground was gone over by Nordgaard in the winter of 1896. The results of these investigations are shown graphically in Plates VI. and VII. The figures in these plates take the form of sections running out from the Norwegian coast to a depth not exceeding 400 metres, and showing the distribution of depth, temperature and salinity. Of these, the most interesting are those made in the same locality in summer and in winter. The difference of season affects principally the water at and near the surface, and is dependent on the rainfall in Norway. If the west coast of Norway were a perpendicular cliff, and the whole of the rain which falls on it ran eastwards, the fluctuation of conditions with which this paper deals would be either non-existent or insignificant. The physical observations of the papers are mainly directed to chronicling the variations in the salinity of the coast waters, and especially in the quantity of water of low salinity, which has a tendency to cover the surface and monopolise the summer heat received from the sun, of which it contributes next to none to the layers immediately below it. This view, that the freshening of the coastal waters, with all its consequences, is due to the mixture of Atlantic water with fresh water from the continent, and not to the addition of water from the Arctic ocean, is developed in considerable detail in the paper. In so far the paper is of a polemical and, indeed, of a more or less national character, because the opposing view is especially identified with Sweden, and the one supported by the authors with Norway. It is, however, a form of polemic from which nothing but profit is likely to result to science. With regard to the evidence afforded by plankton studies, which have been held to favour the Arctic theory, the authors say in their *résumé*:—

"As all inflowing bodies of oceanic water are of an Atlantic kind, the Arctic organisms, which may be met with at certain times, must in any case pass through Atlantic water if they really are derived from the Arctic currents, but their subsequent appearance in the colder and fresher waters on the coast is no proof of the coastal water's Arctic origin."

The concluding paper by Nordgaard, dealing mainly with the food of the cod, is very interesting, but not of a kind to be easily abstracted. In presenting the results of his investigations, he makes some important remarks. He admits that the fluctuations of the herring fishery are largely, though not exclusively, due to changes in the physical conditions of the sea in the spawning regions.

Referring to the cod, he says:—

"We are thus led to the conclusion that a principal factor in the produce of the Lofoten fisheries is the number of the fish that migrate inwards, and as the migration from the ocean, according to the observations hitherto made goes on in such a great depth that the annual variations in the physical conditions are very insignificant, we are obliged to look for another explanation of the change, in the numbers of the immigrations. I am apt to think that much can be derived from changes in the numbers of the fish staying on the outer banks. In the same way in which we speak, for instance, of a bad grouse season, by which we mean that the number of grouse is small, we may certainly also speak of a bad cod season."

It will be seen that this, as well as the preceding papers, are of a very detailed character, and they well repay careful study.

J. Y. B.

## PROJECTIVE GEOMETRY.

*Premiers Principes de Géométrie Moderne.* Par E. Duporcq. Pp. viii + 160. (Paris: Gauthier-Villars, 1899.)

It is a curious fact that while projective geometry is becoming better appreciated in England it seems to be going out of favour in France. M. Duporcq, in his introduction, pathetically deplores the predominant place assigned to analysis in the syllabuses of the official examinations; and in France, as with ourselves, most teachers are compelled to neglect a subject that does not pay. It will be sad indeed if, in the fatherland of Monge, Poncelet and Chasles, pure geometry is to be deposed from her former high estate, and made a kind of Cinderella, called in to do odd jobs for Her Serene Highness the Princess *Analyse*, or to amuse the children with tricks of the triangle.

M. Duporcq's book itself helps us to realise the danger that is threatened. One cannot help feeling that his attitude is apologetic, and that his exposition is a half-hearted one. At the very outset we are confronted with homogeneous coordinates; homography is based on an algebraic relation; points at infinity lie in a plane "by definition"; imaginary elements have no real existence, and the introduction of them, due to analysis, is a mere *façon de parler*, vaguely justified by the "Principle of Continuity." With all respect to Poncelet, it may be doubted whether his "principle of continuity," apart from algebraical considerations, has any real working value; on the other hand, von Staudt elaborated, forty years ago, a theory of imaginary elements which, so far as curves and surfaces of the second order are concerned, gives a consistent geometrical theory (quite independent of analysis) in which the principle of continuity has a real meaning, and is at the same time practically self-evident, as one would expect it to be. Von Staudt's name does not appear to be mentioned in M. Duporcq's book, and the reader might not unreasonably infer that the author was ignorant of v. Staudt's existence.

It would, of course, be absurd to advocate the exclusive use of pure, as opposed to analytical, geometry, even in problems of a strictly geometrical character. The ideal geometrician should be equally expert in both methods, and apply one or the other or both combined according as circumstances may require. But it may fairly be urged that a treatise on the *first principles* of projective geometry should avoid the introduction of coordinates except by way of illustration, and for the purpose of showing the points of contact between the two methods. It is right to teach an apprentice the use of a saw as well as that of a plane; but you will not attain this end by giving him a tool that is neither a saw nor a plane, but contains something of both.

Thus to give an explicit example, M. Duporcq frequently infers homography from a one-to-one relation established, not from an equation, but from the inspection of a figure. Thus (p. 49):

"Si donc $m$ et $m'$ désignent les deux points où une droite quelconque $\Delta$ coupe une conique circonscrite au quadrangle $a\,b\,c\,d$, on voit qu'à tout point $m$ de $\Delta$ ne correspond ainsi qu'un point $m'$. Comme, d'ailleurs, ces points sont évidemment réciproques, ils déterminent donc une involution sur $\Delta$," &c.

These statements are doubtless correct, but are they sufficiently justified? How is the beginner to distinguish the argument from the following:

"Two points S, H are taken on a tangent to an ellipse, and any ellipse with foci S, H cuts the given ellipse in the points M, M′: then to each point M corresponds one point M′ and *vice versâ*, hence we have a system in involution, and MM′ goes through a fixed point"?

It is not a sufficient answer to say that M, M′ are only a pair of four associated points, because this is not geometrically evident. Again, we have cases of Cremona correspondence with the fixed points imaginary: how is the untrained student to distinguish them from homographic correspondences?

We are far from wishing to suggest that M. Duporcq's work is devoid of interest and value. Considering its size it is remarkable for the range and variety of its contents; it comprises a very attractive and, indeed, brilliant sketch of homography, poles and polars, involution, quadratic transformation (including inversion), together with an outline of Lie's line-sphere correspondence. For a reader prepared by previous study, it affords an excellent and suggestive *résumé;* it is rather when it is examined as a methodical text-book for students that it seems to us to fall short of perfection. To the student we would still say: Read Reye, work his exercises, and then, if you like the subject, gird up your loins and tackle von Staudt. For it is a truth past gainsaying that v. Staudt's "Geometrie der Lage" and the immortal "Beiträge" contain, as no other books do, the essentials of projective geometry.

G. B. M.

## A SYSTEM OF PHYSICS.

*Kanon der Physik.* By Felix Auerbach. Pp. xii + 522. (Leipzig: Viet and Co., 1899.)

SCIENTIFIC books may be divided into two groups, those which are written because the author has something to teach, and those which are written because he has something to learn. It is no reproach to a writer if his book is classed with the second group, for there may be as much originality in learning as in teaching, and his autodidactic efforts will often prove a source of instruction to others. It is not possible to say whether Prof. Auerbach has been consciously writing his "Kanon" of physics to clear up his own ideas on scientific principles, but the book he has produced gives the impression that this has been one of his principal motives; and I would even go a step further and say that, if life were long enough, every physicist ought, when he gets to the age of fifty, to spend three years in putting his ideas into shape and write a similar treatise. It would serve as a kind of "Abiturienten Examen" to his state of crystallisation.

It is easier to talk about this book in vague and general terms than to give an account of what it is and what it contains. I am afraid of becoming definite in my own words, for fear of giving a wrong impression, and must content myself with the translation of a few sentences taken out of the preface.

"A comprehensive book is still wanting—and not only in Germany—in which the conceptions, principles,

theorems and formulæ, dimensional relations and numbers belonging to physics are represented and put together in a systematic manner, and in a way which would do justice to two different intentions: to give on the one hand to the reader a general view of the whole, without disturbing him by methodical, historical and other details, and on the other hand to give without circumlocution, to any one who may consult the book, a definite answer to his questions. The great difficulty in principle of such a 'Kanon' of physics lies clearly in the fact that it is in exact science often, perhaps generally, impossible to give a short answer to a short question. If a scientific man is asked, What is mass? What is elasticity? What is entropy? he takes a long breath and begins with a long introduction—and not without reason; for the difficulty of a short and detached answer lies in the nature of the thing. But we must not consider the difficulty to be insurmountable. We must fix our mind on what is essential and characteristic, and give expression to it in our answer; as for the rest, so far as is necessary, it may be added afterwards by supplementary remarks."

The volume which the author has produced to satisfy his requirements is worth reading because it is stimulating. Irritating would perhaps be the better word for the principal sensation felt in perusing it, because we constantly come across statements which do not seem to coincide with our own views, or with explanations which do not satisfy; yet in spite of trying hard, it is difficult sometimes to point out what it is that does not satisfy, and even if one succeeds one feels that the thought one has been obliged to give to the matter has cleared and perhaps modified one's own views. The book begins with a number of chapters on general principles, space, time, motion, force and mass and the properties of matter. The subject is treated in a concise, short and instructive manner, but the author does not always succeed in giving us, as promised in the above passage, a short answer to a short question. His definition of dispersion, *e.g.*, takes up eight lines and wants reading eight times before it can be understood. After a short chapter in which the principal equations of the potential theory are put together and explained, the author enters into the two chief divisions of the book, "energy" and "entropy." He takes a rather wide and unusual view of the latter word, including under it all transformations of energy. Without entering into the difficult question of classification, we may commend these two chapters, which most physicists will read with profit. But surely a better definition of electric current might be given than the one on p. 250:—

"When one observes, that the potential has different values at different points of a conductor, one expresses this fact also by saying: a certain quantity of electricity moves in the conductor, or an electric current flows in it."

The difference of potential at different points is by no means characteristic of an electric current, as for instance in air, where we are constantly dealing with such differences. Dr. Auerbach, to make his explanation correct, must therefore lay stress on a sharp distinction between conductors and non-conductors; but how would he define a conductor except by arguing in a circle, and saying that a body is a conductor when a fall of potential causes an electric current.

Among the points of the book which are irritating without being stimulating, we may mention the very annoying method of numbering concurrently and independently his paragraphs, according as they contain matters of principle or laws and propositions. Thus § 52, printed in fat type, follows § 158 printed in somewhat leaner characters, and whenever a reference has to be looked up, one has to investigate the type carefully, and if it is, *e.g.*, 91 fat, turn to p. 385; while if it is 91 lean, find the required passage on p. 118. We hope that in future editions a different system will be adopted.

Lecturers will find one use, perhaps not a very high one, for this book; it will save them thought and labour, by helping them to arrange their course in a systematic and orderly fashion. ARTHUR SCHUSTER.

## OUR BOOK SHELF.

*Insects: their Structure and Life. A Primer of Entomology.* By George H. Carpenter, B.Sc. (Lond.). Pp. xi + 404. (London: J. M. Dent and Co., 1899.)

MR. CARPENTER, Assistant Naturalist in the Science and Art Museum in Dublin, is favourably known to entomologists by numerous valuable papers on *Lepidoptera*, *Odonata*, cave-insects, economic entomology, &c.; and we are very pleased to welcome a useful introductory manual of entomology from his pen. It is compiled from a variety of sources, special use having been made, in the chapters on the form and life-history of insects, of the well-known work on the cockroach by Profs. Miall and Denny. These chapters will be found very useful, especially as the names attached to the various parts of insects are clearly and carefully explained. Classification and the principal orders and families of insects are then dealt with as fully as the space at the author's disposal would allow; and chapters on insects and their surroundings and on the pedigree of insects close the body of the book, which concludes with a short bibliography and a good index. Perhaps Chapter v., on insects and their surroundings, will be found most interesting to the general reader; for it treats of such subjects as cave-insects, fresh-water insects, marine insects, geographical distribution, mimicry, &c. Mr. Carpenter usually expresses himself very cautiously, but when he says that the number of described species of insects amounts to a quarter of a million, and that there are probably two millions of species still undescribed, we are inclined to think that both his estimates are very much below the mark. The number of described species of insects cannot be less than 300,000 at present, and many entomologists think that the late Prof. Riley's estimate of the number of existing species of insects as ten millions is by no means to be regarded as extravagant. Mr. Carpenter's remarks on the various subjects connected with evolution are very well expressed and reasoned out. W. F. K.

*Year-book of the United States Department of Agriculture*, 1898. Pp. 768. (Washington: Government Printing Office, 1899.)

THE volume before us, like so many of its predecessors which have been noticed in these columns, is full of contributions of interest and value to students of science, agriculturists and others. Although appealing primarily to residents in the States, many useful hints and suggestions may be gleaned from the year-book by its readers in this country. The report of the Secretary of the Department shows that the varied operations carried on have been prosecuted with vigour. The Department has at present four scientific explorers abroad getting seeds and plants—one in Russia, one in the countries

in the neighbourhood of the Mediterranean, one in the China Seas, and one in South America. It is stated in connection with the forestry division that 100,000 acres are under forestry experimentation. The State Agricultural Experiment Stations report an active year, about 400 reports and bulletins having been issued during the year to over half a million addresses. As is fitting at the present time, the volume contains special articles on the resources of Puerto Rico and the Hawaiian Islands.

*Organoterapia.* By Dr. E. Rebuschini. Pp. viii + 442. (Milan: Ulrico Hoepli, 1899.)

IN the introduction Dr. Rebuschini briefly deals with the history and general nature of organotherapy. The main substance of the book is devoted to a detailed account of the glandular secretions and other substances derivable from the several organs of the animal body, and the applications of these fluids to the treatment of disease. As the author points out, the most successful branch of organotherapy up to the present time has been that of the thyroids, and this alone occupies nearly half of the book.

## LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### Undercurrents.

IN NATURE for July 13, p. 261, is given an abstract of a paper lately read by Admiral Makaroff, of the Imperial Russian Navy, before the Royal Society of Edinburgh, on the subject of double currents, *i.e.* of currents in reverse directions in different strata of water in certain straits. Admiral Makaroff gives his opinion on the causes of these reverse currents, and as they are diametrically opposed to those that I hold, I think that it may not be uninteresting to give my reasons for differing from him.

Admiral Makaroff considers that difference of density of the water is the primary and, indeed I gather he thinks, the only cause of these opposing currents; but he brings no evidence beyond theoretical considerations in support of his belief.

Let us consider his instance of the Bosporus.

In 1872, as Admiral Makaroff very kindly mentions, I made a series of observations on the undercurrents in this Strait and in the Dardanelles,[1] and showed that when the surface water, of a very low specific gravity, was flowing from the Black Sea to the Mediterranean, the water in the lower strata of the Straits, of a high specific gravity, was running strong in the opposite direction.

But the surface current does not always flow in this direction. It is sometimes almost still, and on occasions the movement is towards the Black Sea. The lower strata respond, and are either also still, or move in the opposite direction.

It is evident that as the Mediterranean water is always of a high specific gravity, and the Black Sea surface water always of a low specific gravity, if the difference between them is the primary cause of the opposing currents the latter would always flow in the same direction, and that as they do not in fact behave in this manner, there must be some other force at work.

My observations soon led me to conclude that this force is the wind.

The prevailing wind in the summer and autumn, in which I made my observations, is from the N.E. When it blew from this direction, the surface current ran towards the Mediterranean. When it was calm the water was in the Dardanelles, ordinarily, still, and in the Bosporus often so. When the wind came from the westward, the currents were reversed.

I do not know how the deduction from these facts can be got over. I am quite ready to admit that the difference in specific gravity will cause a slow circulation in the direction in which the two currents ordinarily run, but in the face of their undoubted reversal under the circumstances which I have related, it appears to me that there can only be one conclusion.

It was on the ground that the direction of the wind is the prevailing factor that I believed that we should find a similar condition of affairs in the Strait of Bab-el-Mandeb, and as I stated in a communication to NATURE, vol. lviii. p. 544, these conditions were, by observations most ably carried out by Commander Gedge, R.N., in H.M.S. *Stork* in 1898, proved to exist.

There are here none of the differences of specific gravity demanded by Admiral Makaroff's hypothesis, and I consider that the existence of the reverse undercurrent in Bab-el-Mandeb, when the north-east monsoon is forcing the water on the surface into the Red Sea, absolutely proves the correctness of the theory that wind is the primary cause of this interesting circulation. Admiral Makaroff in his paper merely mentions the Strait of Bab-el-Mandeb as a place where the double-currents occur, but says nothing about them; and I am not aware that any observations but those made by H.M.S. *Stork* have been carried out in this Strait.

Admiral Makaroff is a close and indefatigable observer, and oceanography owes him much, but I cannot help thinking that in this instance his enthusiasm for densities has led him away. However, I shall be glad to hear reasons to the contrary, as I only desire the truth.

W. J. L. WHARTON.

Florys, Wimbledon Park, July 25.

[1] Report on the Currents of the Bosporous and Dardanelles. (Hydrographic Office. Potter, London.)

### The Duties of Provincial Professors.

SINCE the appearance of the article "The Duties of Provincial Professors" in NATURE, I have daily been wishing to write to thank you for it, but hitherto have been hindered partly by want of a convenient opportunity, and partly by the feeling that all the points brought forward are so absolutely accurate, and the article is so complete, that it leaves nothing further to be said. The warning it contains as to the danger of making true culture subservient to competition is most timely. I have an experience of many years as an officer in a provincial university college, and know, to my cost, how rank is the growth of the spirit of competition with rival colleges, and how widespreading are its roots. And this is at the sacrifice of the best intellects and ability of the colleges. It results usually in the resignation of the most original and brilliant characters who may have sufficient private means to secure a bare independence; while the others remain quite at the mercy of their governing body, who may at any moment—even without any assigned motive—give them notice to resign. This and the very inadequate salaries attached result in constant changes in the staff. Further, the fever of competition induces the different university colleges to take up technical and pedagogical training, adding department after department at a rate greatly in advance of their means, so that no side can be worked to its full development owing to an insufficient staff and an overburdened exchequer.

A question which has frequently arisen in my mind of late is, Are we to allow without protest a different standard of morals to our governing bodies from that accorded to individuals?

In *bulk* their income is derived from public sources; why should councils of university colleges, whose existence depends upon such sources of income, be allowed the power to close their meetings to reporters? Are they to be allowed freedom of method without danger of exposure? Must we quietly allow them to fix the salaries of their officers at their own pleasure at an average which is much below the market value of the services rendered—in some cases even so low as 50 per cent. below the average rate? Is this honest? No: *it is thieving the best energies of some of our most able minds!*

Those of their officers who lack private means know that they dare not speak the thoughts of their hearts. They hardly dare protest, or courteously ask—even in the most considerate manner, for colleges have their known difficulties—for their legitimate due, for they know very well that, until they have another post to step into, they are helpless.

These things ought not to exist. They are a slow poison sapping the life of true education, rendering systems which are almost ideal in theory of no account in practice.

July 25. VERITAS.

## PHOTOGRAPHIC RESEARCHES ON PHOSPHORESCENT SPECTRA:

### ON VICTORIUM, A NEW ELEMENT ASSOCIATED WITH YTTRIUM.[1]

IT has long been known that certain substances enclosed in a vacuous glass bulb phosphoresce brightly when submitted to molecular bombardment from the negative pole of an induction coil. The ruby, emerald, diamond, alumina, yttria, samaria and a large class of earthy oxides and sulphides emit light under these circumstances. Examined in a spectroscope the light from some of these bodies gives an almost continuous spectrum, while that from others, such as alumina, yttria and samaria, gives spectra of more or less sharp bands and lines. Since 1879 I have been working on these phosphorescent spectra, chiefly in connection with the earths of the yttria group, and by chemical fractionation I have succeeded in separating from this group bodies whose phosphorescent spectra consist chiefly of single groups of lines, other groups being absent. For the last six years the research has been extended beyond the visible spectrum, and photographs of the ultra-violet portion of the spectra are now being taken with a spectrograph with a complete quartz train. Some of the results of this investigation were exhibited at the soirée of the Royal Society on May 3. A preliminary mention of the discovery of a new element was made in my address to the British Association in September last, when I provisionally called it Monium; but for several reasons I now consider the name Victorium more appropriate.

The complicated scheme of fractionation carried on for so many years is illustrated in the accompanying diagram. This must be considered only as an indication of the methods employed, and not as an actual representation of every operation through which the material has passed. Crude yttria, from samarskite, gadolinite, cerite and other similar minerals, is the raw material. The first operation is to free it roughly from earths of the cerium group—an operation effected by taking advantage of the fact that the double sulphates of potassium and the yttrium metals are easily soluble in saturated potassium sulphate solution, while the corresponding double sulphates of the cerium group of metals are difficultly soluble.

After this preliminary treatment, the crude yttria is converted into nitrate, represented by the topmost circle on the diagram. The nitrate is exposed to heat until it fuses to a clear liquid, care being taken to distribute the heat uniformly through the mass. Presently the liquid mass commences to decompose, giving off red vapours. After this has proceeded for a little time, the fused mass is carefully poured into water, and the liquid well boiled. A white precipitate of basic nitrate forms, while the undecomposed nitrates remain in solution. These are separated by filtration—the precipitate going to the right and the solution to the left. The basic nitrate is dissolved in nitric acid, and the right and left solutions are then evaporated to dryness and fused as before. Partial decomposition by heat again divides each of these portions into two lots, soluble and insoluble. The soluble from the left-hand lot goes still further to the left, and its insoluble portion to the right. The soluble from the right-hand portion goes to the left, where it mixes with the insoluble from the other portion, while its insoluble portion goes still further to the right. This series of operations is continued for as long a time as the material will hold out.[2] From a description, the process seems to be more complicated than it really is, but a study of the diagram and the direction of the arrows makes it clear. The number of times this operation is performed varies with each lot of earth fractionated. The portions submitted to fusion rapidly diminish in quantity, and the

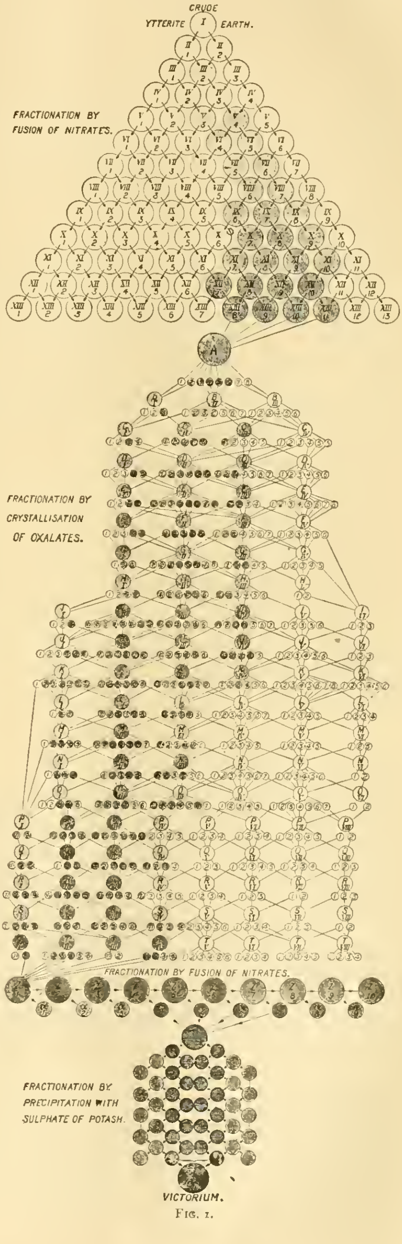

FIG. 1.

[1] A paper read before the Royal Society, May 4, by Sir William Crookes, F.R.S.

[2] "On the Methods of Chemical Fractionation," British Association, Birmingham Meeting, 1886; *Chemical News*, vol. liv. p. 131.

operation is continued until the material becomes too scanty.

The last horizontal line of fractions, spectroscopically examined in a radiant matter tube, shows differences in the visible spectrum. For many years I recorded these differences in coloured drawings, which have served on several occasions to illustrate papers before this Society.[1] In the year 1893 I commenced to record the differences between the various spectra by photographing them in a spectrograph having a complete quartz train, and since that time attention has chiefly been directed to the variations in the number, character and positions of the lines and bands in the ultra-violet spectrum; these are more striking than those which are visible, and as they are self-recording, results are more rapidly attained. A description of this instrument is given further on.

On placing the photographed spectra of one of the horizontal lines of earths in order, several differences are detected. One striking difference is seen in the behaviour of a group of lines in the ultra-violet. It is nearly absent in the end fractions, gradually becoming stronger towards the middle, and attaining a maximum in the fractions situate about two-thirds towards the right. This shows that at least three different bodies are present: one, the great bulk, having a nitrate difficult to decompose; another, whose nitrate is easiest to decompose; and a third body, occupying an intermediate position, whose nitrate decomposition occurs at temperatures between that required by the others, but nearer that of the nitrate easiest decomposed.

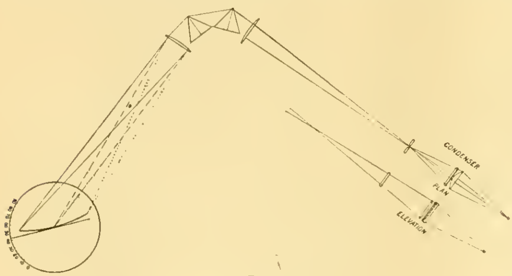

FIG. 2.

The above method of fractionation is not so effectual if more than two bodies are present. In that case the process fails, in any reasonable time, to yield practically pure specimens of more than two out of a group of closely allied earths. Thus, if there are three earths—say A, B and C—whose positions in reference to the chemical process employed are in the written order of sequence, we may get a specimen of A as nearly as we please free from B and C, and a specimen of C as nearly as we please free from A and B, but we cannot get a specimen of B practically free from A and C. The law seems to be that to obtain practically pure specimens of three closely allied earths, it is essential to have recourse to at least two different chemical processes. The mere continued repetition of the same process will not do, unless, indeed, the operations are repeated such a vast number of times as to make the approximate expressions no longer applicable, even though the substances are chemically very close.

For this and other reasons it is advisable to change the method of fractionation after one process has been in operation for some time. It is evident that any process of fusion, crystallisation or precipitation can only divide the mass of material into two parts, a soluble and an insoluble portion, crystals and mother liquor; and after a time a balance of affinities seems to be established, and further fractionation appears to do little good. It is better then to change the operation.

Following the diagrammatic scheme, the portions of earths containing most victorium are collected together and fractionated by the crystallisation of the oxalates from a solution strongly acidulated with nitric acid in the following manner:—

To a boiling acid solution of the nitrate a small quantity of hot solution of oxalic acid is added. The solution remains clear, and it is only after vigorous stirring that a small quantity of insoluble oxalate is formed. The whole is thrown on a hot-water filter and slightly washed with boiling water. To the boiling filtrate a fresh lot of hot solution of oxalic acid is added, and stirred till more insoluble oxalate comes down. This is again filtered off, and the operations of precipitating, stirring, filtering, and washing are repeated, always keeping the temperature as near the boiling point as possible, until the whole of the earths are precipitated. Generally the initial earth is divided by this method of fractionation into from six to twelve portions. Each of these oxalates is dried, ignited, dissolved in nitric acid, and the above-described operations repeated. Photo-spectroscopic tests are constantly taken during the progress of this fractionation, and portions are mixed together according to the data thus obtained, as shown on the diagram by the lines joining the fractions. The object being to avoid lateral spreading as much as possible, and, while concentrating the special line-giving earth, to prevent its too great diffusion over a large number of fractions. When the fractionation by the oxalate method has proceeded for a considerable time, the fractions rich in victorium are collected together and submitted to another mode of treatment.

These fractions are converted into nitrates, and a small quantity is thrown out by partial decomposition by heat, according to the method already described. The filtrate is evaporated to dryness and again fused, so as to throw out a little more. This operation is repeated as long as any soluble nitrate is left. Generally from six to twelve portions are thus obtained. These form a regular series, differing according to the stability of the nitrate under heat. On testing, the victorium is found to concentrate in the centre portions, being less easily decomposed than the earths of the cerium group, and more easily decomposed than those of the yttrium group.

The fractions rich in victorium are converted into sulphates and mixed with a hot saturated solution of potassium sulphate. The precipitate is dissolved in boiling water and mixed with a further quantity of solution of potassium sulphate. This produces a small quantity of a precipitate. The filtrate from the first precipitate is also mixed with fresh potassium sulphate, and the operations are repeated, mixing the centre solutions to one lot and the side solutions to another, as shown by the lines on the diagram. It is found on photo-spectroscopic examination that the earths thrown out on each side are poorest in victorium, whilst those in the middle are richest. After a time no further concentration is effected in this manner, all the earths that can be removed as being more or less soluble in potassium sulphate having been eliminated.

In thus describing the method of fractionation, my object has been not so much to give a description of the plan actually carried out in the laboratory—for the details have varied with each operation—but to give an intelligible idea of the general manner in which a very complicated operation is effected. In the diagram I am supposing that one particular substance, victorium, is to

[1] "On some New Elements in Gadolinite and Samarskite Detected Spectroscopically" (*Roy. Soc. Proc.*, No. 245, 1886 vol. xl. p. 502).

be separated, and I have endeavoured to show its migrations and gradual concentration as the work progresses, by tinting the fractions where it mostly would concentrate, the depth of tint representing the amount of concentration.

In the purest condition yet obtained victoria is an earth of a pale brown colour, easily soluble in acids. It is less basic than yttria and more basic than most of the earths of the terbia group. In chemical characters it differs in many respects from yttria. From a hot nitric acid solution victorium oxalate precipitates before yttrium oxalate and after terbium oxalate. On fractional precipitation with potassium sulphate the double sulphate of victorium and potassium is seen to be less soluble than the corresponding yttrium salt, and more soluble than the double sulphates of potassium and the terbium and cerium groups. Victorium nitrate is a little more easily decomposed by heat than yttrium nitrate, but the difference is not sufficient to make this reaction a good means of separating victorium and yttrium. Fusing the nitrates can, however, be employed advantageously to separate mixed victoria and yttria from the bulk of their associated earths.

On the assumption that the oxide has the composition $Vc_2O_3$, the atomic weight of victorium is apparently not far from 117.

The photographed phosphorescence spectrum of victoria consists of a pair of strong lines at about $\lambda$ 3120 and 3117; other fainter lines are at 3219, 3064, and 3060. Frequently the pair at 3120 and 3117 merge into one, but occasionally I have seen them quite distinct. The presence or absence of other earths has much influence on the sharpness of lines in phosphorescent spectra, and it is probable that these lines will be sharp and distinct when victoria is obtained quite free from its associates.

The best material for phosphorescing in the radiant matter tube is not the earth itself, but the anhydrous sulphate formed by heating the earth with strong sulphuric acid and driving off the excess of acid at a red heat. The sulphate thus produced, probably also containing some basic sulphate, is powdered and introduced into a bulb tube furnished with a quartz window, and a pair of thick aluminium poles sealed into the glass with stout platinum wires. The tube is well exhausted, keeping the current from a good induction coil going all the time. The pumping and sparking must continue until the earth glows with a pure light free from haze or cloudiness, and continues so to glow during the passage of the current without deterioration. The exposure in the spectrograph usually occupies an hour.

I give a diagrammatic plan of the two-prism spectrograph used in this research. It is furnished with two quartz prisms, quartz lenses and condensers. The slit jaws are of quartz, cut and polished according to the method I described in the *Chemical News*, vol. lxxi. p. 175, April 11, 1895.

The prisms are made in two halves according to Cornu's plan, one half of each being right-handed and the other half left-handed. One of the lenses also is right-handed and the other left-handed. By this device the effect of double refraction is so completely neutralised that with a five-prism instrument it is impossible, under high magnifying power, to detect any duplication of the lines.

The lenses are each of 52 mm. diameter and 350 mm. focus. The focus of the least refrangible rays is longer than that of the most refrangible rays, and the sensitive film must therefore be set at an angle to get the extreme rays into focus at the same time. But this alone is not sufficient. The focal plane is not a flat surface, but is curved, and the film must therefore be curved,[1] and it is only when both these conditions are fulfilled that perfectly sharp images of spectral lines extending from the red to the high zinc line 2138·30 can be photographed on the same surface. Celluloid films are used, glass not being sufficiently flexible.

Using the middle position showing the whole spectrum on a plate, the angle is 40°, and the curvature is 190 mm. radius.

The condensers are of quartz, and are plano-cylindrical — one being double the focus of the other. The object of this, when spark-spectra are being photographed, is to concentrate on the slit a line instead of a point of light, as would be the case if ordinary lenses were used.

When photographing phosphorescent spectra—or, in fact, any spectra the wave-lengths of which are either unknown or require verification—I always photograph on the same film a standard spectrum, usually of an alloy of equal molecular weights of zinc, cadmium, tin and mercury. This forms a hard, somewhat malleable alloy, giving throughout the whole photographic region lines the wave-lengths of which are well known. The chief objection to this alloy is its volatility, the poles requiring frequent adjustment. Recently I have used pure iron for this purpose; this has the advantages of giving a great number of fine lines whose wave-lengths are accurately known, and not being very volatile, the poles do not rapidly wear away. If the poles are kept about 1 mm. apart, there is little or no interference from air lines.

The most simple method of applying the standard lines to an unknown spectrum is by the successive employment of two slightly overlapping diaphragms immediately behind the slit, one being used for the experimental and the other for the standard spectrum. In this way, without disturbing the instrument, the two spectra can be recorded on the plate one over the other; the overlap of 1 mm. being in the optical centre of the train. The resulting negative is then transferred to a micrometer measuring machine of special construction, having a screw of 1/100th of an inch pitch, and a means of accurately determining 1/1000th of its revolution, thus measuring directly to the 1/100000th of an inch. In this way, in a five-prism spectrograph having lenses 700 mm. focus, it is possible to determine wave-lengths of photographed lines to the sixth figure.

[1] *Chemical News*, vol. lxxii. p. 87, August 23, 1895; and vol. lxxiv. p. 259, November 27, 1896.

## *MATHEMATICS OF THE SPINNING-TOP.*[1]

### I.

"TO those who study the progress of exact science, the common spinning-top is a symbol of the labours and the perplexities of men who had successfully threaded the mazes of the planetary motions. The mathematicians of the last century, searching through nature for problems worthy of their analysis, found in the toy of their youth ample occupation for their highest mathematical powers.

"No illustration of astronomical precession can be devised more perfect than that presented by a properly balanced top, but yet the motion of rotation has intricacies far exceeding those of the theory of precession.

"Accordingly we find Euler and D'Alembert devoting their talent and their patience to the establishment of the laws of the rotation of solid bodies. Lagrange has incorporated his own analysis of the problem with his general treatment of mechanics; and since his time Poinsot has brought the subject under the power of a more searching analysis than that of the calculus, in which ideas take the place of symbols, and intelligible propositions supersede equations" (Maxwell—"Collected Works," I. p. 248).

Newton also cites the top as affording an experimental verification of his First Law of Motion—Lex. I. ". . .

[1] "Ueber die Theorie des Kreisels." F. Klein und A. Sommerfeld. Heft i, ii. Pp. 196 and 197 to 512. (Leipzig: Teubner, 1897–8.)

Trochus, cujus partes cohaerendo perpetuo retrahunt sese a motibus rectilineis, non cessat rotari, nisi quatenus ab aere retardatur." We can translate *trochus* as a top, as well as a wheel or hoop.

But Newton lived too early to calculate any quantitative explanation of the theory of the top, and even his attempt at the simpler problem of precession was not a very great success. (Principia, lib. III., Prop. xxxix.) We had to wait for D'Alembert to straighten out the difficulties of first principles before arriving at an exact solution.

The key-note of the present treatise is found in § 2—"Analytische Darstellung der Drehungen um einen festen Punkt"—and in the bilinear relation in equation (5) on p. 25,

$$(1) \qquad \lambda = \frac{\alpha\Lambda + \beta}{\gamma\Lambda + \delta}, \text{ with } \alpha\delta - \beta\gamma = 1,$$

expressing analytically the displacement of a rigid body about a fixed point.

If $x, y, z$ are the coordinates of a point with respect to axes fixed in space, and X, Y, Z of the same point with respect to axes fixed in the body,

$$(2) \qquad \lambda = \frac{x + yi}{r - z} = \frac{r - z}{-x + yi},$$

while $\Lambda$ is the same function of X, Y, Z; thus $\lambda$ and $\Lambda$ play the part of a stereographic representation of the point on the sphere of radius $r$ with respect to the poles in which the sphere is intersected by the axes O$z$ and OZ.

Expressed by Euler's unsymmetrical angles $\theta, \phi, \psi$,

$$(3) \qquad \alpha = \cos\tfrac{1}{2}\theta e^{\frac{1}{2}(\phi+\psi)i}, \qquad \beta = i \sin\tfrac{1}{2}\theta e^{-\frac{1}{2}(\phi-\psi)i}$$

$$\gamma = i \sin\tfrac{1}{2}\theta e^{\frac{1}{2}(\phi-\psi)i}, \qquad \delta = \cos\tfrac{1}{2}\theta e^{-\frac{1}{2}(\phi+\psi)i},$$

satisfying

$$\alpha\delta = \cos^2\tfrac{1}{2}\theta, \qquad \beta\gamma = -\sin^2\tfrac{1}{2}\theta,$$

and

$$\alpha\delta - \beta\gamma = 1.$$

By putting

$$(4) \qquad \alpha = D + Ci, \qquad \beta = -B + Ai,$$
$$\gamma = B + Ai, \qquad \delta = D - Ci,$$

so that

$$A^2 + B^2 + C^2 + D^2 = 1,$$

the versor-quaternion

$$(5) \qquad Q = Ai + Bj + Ck + D$$

is obtained, which determines the displacement; this gives the authors an opportunity for an excursion into the Quaternion-Theory so far as required in their subject, and should delight the soul of Prof. Tait, always anxious to see more frequent applications of his favourite subject, to which allusion is made on p. 509.

In Maxwell's opinion, it is the introduction of the ideas, as distinguished from the operations and methods of Quaternions, which is valuable; and now we have McAulay's "Octonions" to assist, with plentiful illustrations of the dynamics of our subject.

The important use of the above bilinear relation between $\lambda$ and $\Lambda$, for the treatment of the motion of a rotating body or a top, was pointed out by Prof. Klein in a lecture at Göttingen University in the winter-semester of 1895; the further development of the formulas was chosen by Prof. Klein as the subject of his Princeton Lectures in October 1896; and the present work is intended to be a complete presentation, with the collaboration of Prof. Sommerfeld.

Subsequent historical research, described on p. 511, has shown that the germs of similar ideas can be traced back through Hess (p. 429), Weierstrass (p. 511), up to Gauss in 1819. Gauss appears at the same time to have had some prophetic inspirations of the Quaternionic Theory, but as usual he carefully bottled up his ideas. It was said of the works of Friar Roger Bacon in the middle ages—"partim mutili direptis hinc inde quaternionibus facti, tam raro comparent, ut facilius sit Sibyllae folia colligere quam nomina librorum quos scripsit"—and the same might be said of Gauss's unpublished manuscripts, now at length to be edited completely by the Göttingen Academy of Sciences, under the direction of Prof. Klein, the present occupant of Gauss's chair. We think then that Prof. Klein is too generous in renouncing the priority of his discovery, considering that he was the first to make the invention really work, and that his precursors allowed the germs of the idea to pass from them unfertilised, not perceiving their real importance.

In the special case of the symmetrical top the functions $\alpha, \beta, \gamma, \delta$ can be expressed by elliptic-theta functions; Prof. Klein calls them "multiplicative elliptic functions"; their form is given explicitly on p. 520, and now the solution is complete from the point of view of the mere mathematician of the school of—"Shut your eyes and write down equations."

"Mais il faut convenir que, dans toutes ces solutions on ne voit guère que des calculs, sans aucune image nette de la rotation du corps."

The authors, giving heed to this warning of Poinsot, devote the rest of the book to a careful examination and classification of the various cases which may occur; and also to what the ordinary mathematician in general so cordially detests, the working out and drawing in a diagram of some well-chosen numerical cases; only in this way is it possible to make sure of the accuracy and reality of the abstract formulas, and to lift mathematical science out of the arid collection of analytical results.

A first great requirement for the study of the movement of the top is an actual model, as shown on p. 1, or else a top such as that devised by Maxwell ("Collected Works," I. p. 248); sufficient rotation can be imparted by twirling the spindle by the finger; and a slight blow with the hand will give any desired variety to the pattern of the curve described by the end of the axle. A bicycle wheel, spinning in its ball bearings, supported in a fixed cup, would also serve the purpose.

As we have three independent constants at our disposal with the top, the number of possible cases is threefold infinite ($\infty^3$); and so the choice of a numerical case is at first sight an embarrassing one in its variety.

In the book the constants employed are such that (p. 223)

$$(6) \qquad t = \int \frac{du}{\sqrt{U}}, \quad u = \cos\theta,$$

$$(7) \qquad \psi = \int \frac{n - Nu}{A(1-u^2)} \frac{du}{\sqrt{U}}$$

$$(8) \qquad \phi = \int \frac{N - nu}{A(1-u^2)} \frac{du}{\sqrt{U}} + N\left(\frac{1}{C} - \frac{1}{A}\right)t$$

$$(9) \qquad A^2U = (1-u^2)(k - N^2 - 2APu) - (n - Nu)^2$$
$$= (1-u^2)(k - n^2 - 2APu) - (N - nu)^2.$$

Here we must make the criticism that until p. 299 the mechanical interpretation of the quantities P, $n$, N is not very clearly defined so as to have their numerical values assigned in the C.G.S. system of units. Given the top we are to experiment with, we must first weigh it; denote the weight by W grammes; next measure the distance, $h$ cm., between the C.G. and the point of support; then W$gh$, dyne-cm., is the static moment denoted here by P, $g$ denoting the acceleration of gravity (981) in cm./s.$^2$. The number A denotes, as usual, the moment of inertia, in g.cm.$^2$, of the top about an axis through its point perpendicular to its axis of figure; A can be determined experimentally by swinging the top as a plane or conical pendulum, and measuring the length of the equivalent pendulum, $l$ cm., and the angular velocity $m$ when swung without rotation as a conical pendulum of small aperture; then

$$l=\frac{A}{Wh}, \quad A=Whl=\frac{Pl}{g},$$

and

$$m^2=\frac{g}{l}=\frac{Wgh}{A}=\frac{P}{A}.$$

So also C denotes, as usual, the moment of inertia, in g.cm.$^2$, about the axis of figure, and, with an angular velocity $r$ rad./sec. about the axis of figure, $N = Cr$, the angular momentum about the axis; while $n$ is the constant angular momentum round the vertical $Oz$.

In the discussion of the numerical cases, the authors start by taking a root $u = e$ of the cubic $U = 0$ as given, and then examining the various relations which subsist between N and $n$. But if one root of the cubic is known, the other two are determined by the solution of a quadratic, so that we may take all these roots as the three data of the question, and follow Darboux's method, as explained in the notes to Despeyrous' "Cours de Mécanique."

We may, for symmetry with Weirstrass' notation, denote the two extreme limits of $\theta$ by $\theta_2$ and $\theta_3$, so that $\cos\theta_2$ and $\cos\theta_3$ are two roots of the cubic U; the third root, being greater than unity, may be denoted by $\operatorname{ch}\theta_1$, and now

$$A^2U=2AP(\operatorname{ch}\theta_1-\cos\theta)(\cos\theta_2-\cos\theta)(\cos\theta-\cos\theta_3)$$
$$=2APV$$

suppose, with

$$\operatorname{ch}\theta_1>\cos\theta_2>\cos\theta>\cos\theta_3.$$

It is not clear how any simplicity is gained by considering negative as well as positive values of P (p. 248); this seems to introduce needless complication in the classification, as we can take P always positive, and measure the angles $\theta_2$ and $\theta_3$ from the upright vertical position of the top. There may be a slight disadvantage in the case of the spherical pendulum, in which the chief part of the motion takes place in the lower hemisphere, but the counterbalancing advantages of simplicity of classification prevail on the whole.

In Darboux's representation of the motion of the axis by means of the generating lines of a deformable hyperboloid, we take a focal ellipse, of which the ratio of the axes is equal to the modulus $\kappa$ of the real period; the comodulus $\kappa'$ of the imaginary period $\omega'$ is thus the eccentricity of the focal ellipse; and

(10) $$\kappa^2=\frac{\cos\theta_2-\cos\theta_3}{\operatorname{ch}\theta_1-\cos\theta}, \quad \kappa'^2=\frac{\operatorname{ch}\theta_1-\cos\theta_2}{\operatorname{ch}\theta_1-\cos\theta_3}.$$

The two generating lines HP and HP′ are placed in position at an angle $\theta_3$ as tangents to the focal ellipse, and the deformable hyperboloid is completed in Henrici's manner by a number of other rods as tangent lines, knotted together at the points of crossing. With this model we can represent graphically the various constants of the problem.

Returning to the case considered by the authors, where $\theta_3$, N, and $n$ are given, we can select an arbitrary length OD, and measure off lengths HQ, HQ′ along two straight lines inclined at an angle $\theta_3$, such that

(11) $$\frac{HQ}{OD}=\frac{n}{2\sqrt{AP}}, \quad \frac{HQ'}{OD}=\frac{N}{2\sqrt{AP}};$$

and draw the perpendicular QO, Q′O to the lines meeting in O. We are now given the conjugate semi-diameters OH and OD, by which the ellipse can be described through H, and the confocal ellipse, touching HQ and HQ′, is the focal ellipse of the deformable hyperboloid.

On this diagram

(12) $$\cos\theta_3=\frac{OH^2-AB^2}{OD^2}, \quad \sin\theta_3=2\frac{OS\cdot OM}{OD^2},$$

$$\cos\theta_2=\frac{OH^2-OS^2}{OD^2}, \quad \sin\theta_2=2\frac{OS\cdot ON}{OD^2},$$

$$\operatorname{ch}\theta_1=\frac{OH^2+OS^2}{OD^2}, \quad \operatorname{sh}\theta_1=2\frac{OQ\cdot HP}{OD^2};$$

$$\frac{k}{2AP}=\frac{3OH^2-AB^2}{OD^2}=\operatorname{ch}\theta_1+\cos\theta_2+\cos\theta_3.$$

If $\theta_1$, $\theta_2$, $\theta_3$ are given, then

$$e^{\theta_1}=\frac{HS'}{HS}, \text{ while } \frac{\operatorname{ch}\theta_1}{\cos\theta_2}=\frac{OH^2+OS^2}{OH^2-OS^2},$$

from which, when the focal ellipse is drawn, the position of H and the tangents HP, HP′ can be drawn.

The angle AOQ is the amplitude function of a certain fraction $fK'$ of Jacobi's quarter period K′, with respect to the co-modulus $\kappa'$, the eccentricity of the focal ellipse; denoting AOQ by $\omega$, then, in Legendre's notation,

(13) $$F\omega=fK',$$

whence the fraction $f$ can be determined from his tables; so also the fraction $f'$ for AOQ′.

In connection with the dynamical interpretation there is an important point L in the tangent HP, such that, in Jacobi's notation for the Zeta-function,

(14) $$QL=OAZfK'$$
$$LV,\ LT,\ LP=OA\,(zs,\ zc,\ zd)fK'.$$

Expressed in Legendre's notation

$$ZfK'=E\omega-fE,$$

from which the position of L can be calculated by Legendre's Tables; and now a reduction of the elliptic integrals of the third kind in (7) will show that the apsidal angle

(15) $$\Psi=\frac{HL}{OA}K+\tfrac{1}{2}f\pi.$$

Integral (6) for the time $t$ gives

(16) $$mt=\int\frac{du}{\sqrt{2V}}=\frac{F\phi}{\sqrt{\tfrac{1}{2}(\operatorname{ch}\theta_1-\cos\theta_3)}}=\frac{OD}{OA}F\phi,$$

where

(17) $$\cos\theta=\cos\theta_3\cos^2\phi+\cos\theta_2\sin^2\phi,$$

a different use of $\phi$ to that employed in (8).

Thus if T is the time taken by the axis to swing between the extreme inclinations $\theta_3$ and $\theta_2$,

(18) $$mT=\frac{OD}{OA}K.$$

When H is at T, $N=n$, and the rosette curves described by Prof. Klein are obtained, in which the axis passes periodically through the highest vertical position, shown in Figs. 55, 56, 57. When H is at V, $N=n$ again, but now the axis describes an intermediate path, never becoming vertical. When H is at P, $N=-n$, and $\cos\theta_3=-1$; the axis now describes a new series of rosette curves, all passing through the lowest vertical position. These rosette curves are shown in one of Mr. T. I. Dewar's stereoscopic diagrams.

If we make $\kappa=1$, the focal ellipse becomes circular, and now $N=n=2\sqrt{AP}\cos\tfrac{1}{2}\theta_3$, and the axis reaches the highest vertical position asymptotically, the case represented in Fig. 58; and the hyperboloid shuts up into the axis, like a deformable napkin-ring.

Having settled upon a certain modulus $\kappa$, and a certain fraction $f$, which gives the tangent TPQ of the focal ellipse, we can examine the variety of cases which arise by taking different positions of H on this tangent.

In the spherical pendulum $N=0$, so that H must be placed on the pedal of the ellipse with respect to the centre O; and now

(19) $$\cos\theta_3=-\frac{OQ}{OH}=-\frac{\operatorname{dn}fK'}{\operatorname{dn}f'K'};$$

and similarly

$$\cos\theta_2=-\frac{\operatorname{cn}fK'}{\operatorname{cn}f'K'}, \quad \operatorname{ch}\theta_1=\frac{\operatorname{sn}fK'}{\operatorname{sn}f'K'}.$$

When H is on the tangent at B or B′, the curve described by points on the axis have cusps; when H lies between these points, the curves are looped, and the associated herpolhode has points of inflexion.

In steady precessional motion $\kappa=0$, and the focal ellipse coalesces with the line SS′; now $f=0$ and $K=\frac{1}{2}\pi$, so that the apsidal angle

(20) $$\Psi=\frac{HS}{OS}\tfrac{1}{2}\pi.$$

If $\mu$ denotes the constant angular velocity of precession,

$$\mu T=\Psi,\quad mT=\frac{OD}{OS}\tfrac{1}{2}\pi,$$

so that

(21) $$\frac{\mu}{m}=\frac{HS}{OD}.$$

The steady motion relations

(22) $$P=N\mu-A\mu^2\cos\alpha,\quad n=A\mu\sin^2\alpha+N\cos\alpha,$$

when $\alpha$ denotes, instead of $\theta_3$, the constant inclination of the axis to the vertical, will be found, on eliminating $\mu$, to be equivalent to the geometrical relation

(23) $$OQ\,.\,OQ'=\tfrac{1}{4}OD^2\sin^2\alpha,$$

so that O lies on a certain hyperbola, $xy=\frac{1}{4}OD^2$, referred to HQ, HQ′ the asymptotes as axes; thus given N and $\alpha$, a geometrical construction will determine the solution of the problem.

Having selected OD arbitrarily, the hyperbola is drawn, and then having laid off HQ′ to scale, draw Q′O at right angles to the asymptote HQ′ to meet the hyperbola in O; the tangent to the hyperbola at O will meet the asymptotes in S and S′.

The second solution will depend on the second point O′ in which Q′O cuts the hyperbola. To realise the state of motion shown in Fig. 28, the point O on the hyperbola must be close to the asymptote.

It is very desirable that a penultimate case of this nature should be worked out completely. We have the requisite analysis for the calculation of the algebraical case when there are 22 cusps, but the work would require the arithmetical courage of a Dewar, now unfortunately no longer available.

Supposing that in consequence of the friction of the pivot the motion has steadied down to uniform precession, then a $\begin{pmatrix}\text{following}\\\text{heading}\end{pmatrix}$ tap on the spindle, to $\begin{pmatrix}\text{hurry}\\\text{delay}\end{pmatrix}$ the precession makes O move along OQ and produces a focal $\begin{pmatrix}\text{ellipse}\\\text{hyperbola}\end{pmatrix}$ and the axis $\begin{pmatrix}\text{rises}\\\text{falls}\end{pmatrix}$.

A tap in the vertical plane makes O start out normally to the plane, and the lines HQ, HQ′ are now generating lines of Darboux's hyperboloid, in an intermediate position.

Once the limits $\theta_2$ and $\theta_3$ are assigned, and the corresponding apsidal angle $\Psi$, a regular curve satisfying these conditions drawn empirically will give an idea of the complete curve described by the axis.

But if it is desired to plot a number of intermediate points from tabular matter of the elliptic functions, we are baffled by the mixture of the real and imaginary arguments of the theta-functions required in the calculation of $\psi$ and $\phi$, although $\theta$ is readily calculated by equation (17). A courageous attempt at this computation is made in IV. 8, by Herr Blumenthal, but the hidden rocks of error are numerous and plentiful enough to make this procedure dangerous. If the calculation of a number of guiding points between the extreme points of a branch of the spherical curve is required, we had better utilise Jacobi's theorem, that the curve described in a horizontal plane round the vertical OG by the extremity of the vector OH of resultant angular momentum is a Poinsot herpolhode; and having plotted this herpolhode, the vertical plane defined by $\psi$ may be drawn perpendicular to the tangent HK of the herpolhode, while a simple relation of the form

(24) $$\cos\theta+2\frac{OH^2}{OD^2}=\frac{k}{2AP}=\text{ch}\,\theta_1+\cos\theta_2+\cos\theta_3,$$

will give the corresponding value of $\theta$, and hence the spherical curve, or its projection, orthographic or stereographic, can be plotted to any desired accuracy.

This theorem of Jacobi is almost self-evident when interpreted by means of Darboux's representation of the motion by the deformable articulated hyperboloid.

In this method the rod OG is held in the vertical position, and the point H is guided round the herpolhode; and then OG, connected by the articulation, will imitate the movement of the axis of the top; for a quadric surface can be drawn through H coaxial with the articulated hyperboloid, and normal to HP at H, and the squares of the semi-axes of this quadric will be, by a well-known theorem of solid geometry

(25) $$HQ\,.\,HV,\quad HQ\,.\,HT,\quad HQ\,.\,HP,$$

with proper attention to sign; and these being fixed lengths, the quadric is a fixed quadric.

Its equation may be written

(26) $$Ax^2+By^2+Cz^2=D\delta^2,$$

with

(27) $$\delta=HQ;\quad \frac{D}{A}=\frac{HV}{HQ},\quad \frac{D}{B}=\frac{HT}{HQ},\quad \frac{D}{C}=\frac{HP}{HQ}(\pm),$$

the $\pm$ sign being taken according as Q and V, T, P are on the $\begin{pmatrix}\text{same}\\\text{opposite}\end{pmatrix}$ sides of H.

An accent will serve to distinguish the case where a fixed quadric rolls on the plane through H perpendicular to HP′; and now we see why the same polhode described by H with respect to the axis of the articulated hyperboloid has associated with it two distinct herpolhodes.

(*To be continued.*)

## LIFE-HISTORY OF THE PARASITES OF MALARIA.

THE parasites which cause malarial fevers in human beings belong to a very homogeneous group, other species of which are found in certain bats and birds. The life-history of the three species of this group which have been completely studied is as follows. The youngest parasites exist as amœbulæ or myxopods within the red blood corpuscles of the vertebrate host. Each amœbula possesses a nucleus and nucleolus; and its movements vary in extent and rapidity with the species, but, in the case of birds, never encroach upon the nucleus of the corpuscle. The amœbulæ increase in size; and, as they do so, tend to lose their movements and to accumulate in their ectoplasm certain black granules, the pigment or melanin, which are the product of assimilation of the hæmoglobin of the corpuscle. In from one to several days the parasites reach their highest development within the vertebrate host, and become either (*a*) sporocytes or (*b*) gametocytes.

The sporocytes, which are produced asexually, contain spores which vary in number according to the species. The spores do not possess any appreciable cell-wall. When they are mature the corpuscle which contains them bursts and allows them to fall into the serum. They then attach themselves to fresh blood corpuscles, and continue the propagation of the parasites indefinitely in the vertebrate host. The residuum of the sporocyte, consisting chiefly of the pigment, is taken up by the phagocytes of the host for eventual disposal in the host.

The gametocytes, while in the blood of the vertebrate host, are still contained in the shell of the corpuscle.

In some species their general form and appearance is very like that of the sporocytes before the spores are differentiated; in another, however, they possess a special crescentic form. They continue to circulate in the blood for some days, or even weeks (according to the species), without change; but when they are drawn into the alimentary canal of certain suctorial insects, they undergo further development. In a few minutes after finding themselves in their new position, they break from the enclosing corpuscle by a kind of expansion, swell up slightly, and then commence their sexual functions. The male gametocytes emit a variable number of microgametes, which escape into the serum of the ingested blood, leaving behind a residuum consisting chiefly of pigment—as in the case of the sporocytes. The individual microgametes are delicate but very active filaments, consisting chiefly of chromatin, and sometimes seen to have a slight swelling at one point of their length —in the middle, when free, according to my observations. After escape from the male gametocyte, the microgametes seek the female gametocytes, which consist each of a single motionless macrogamete. One microgamete now enters bodily into a macrogamete and fertilises it, producing a zygote.

The further history of the zygote has been traced, as regards three species of this group of parasites, in certain kinds of mosquitoes. After being fertilised, it acquires the power of escaping the phagocytes of the ingested blood which surround it, of working its way through the mass of blood, of passing through the thickness of the stomach (middle intestine) of the mosquito, and of affixing itself to the outer surface of the organ. Here the zygotes are first found as oval cells about 8-10 $\mu$ in diameter. They still contain the granules of pigment which the macrogametes possessed before fertilisation. Growing rapidly, they soon acquire a capsule, and begin to protrude into the body-cavity of the mosquito. From an early period the nucleus divides into a number of portions—zygotomeres—each containing a fragment of chromatin. As growth advances, the zygotomeres become spherical blastophores, bearing each a large number of delicate, filamentous zygotoblasts on their external surface—each zygotoblast being affixed to the surface of the blastophore by one extremity. As maturity is approached the zygote, though still attached to the outer wall of the insect's stomach, protrudes freely into the body-cavity; its pigment tends to disappear; and lastly, the blastophores disappear, leaving the capsule packed with thousands of zygotoblasts. Maturity is reached in from one to three weeks, according to the external temperature, when the zygote reaches a size of 60 $\mu$ or more. The capsule then ruptures, pouring the zygotoblasts into the insect's blood.

The zygotoblasts are now seen to be delicate flagellulæ or mastigopods, about 12-16 $\mu$ in length, with the chromatin and one or two unstained areas in the middle, and two opposite tapering flagella. I have not, however, observed any notable movement in them, probably on account of the necessary dissecting medium. After being discharged into the insect's blood, these bodies are carried away by the current into all parts of the tissues, and finally effect an entry into the large grape-like cells of the salivary gland—especially the cells of the short middle lobe—where they accumulate in very large numbers. From the cells of this gland they pass into the duct which runs to the extremity of the middle stylet, the lingula, and thence escape during haustellation into the blood of a new vertebrate host. Here, it must be supposed, the flagellulæ attack the corpuscles and become the intra-corpuscular amœbulæ with which we started.

Four points require notice. (1) There are reasons for supposing that the gametocytes are or may be produced by the conjugation of two or more amœbulæ in one corpuscle. (2) The gametocytes of several species show, after escape from the corpuscle, one or more minute spherical bodies attached to their margin; which I assume to represent polar bodies. (3) The young zygote of at least one species (of crows) possesses, shortly after fertilisation, somewhat active powers of locomotion. (4) The mature zygotes of at least two species often contain large, brown, thick-shelled, cylindrical bodies, the nature of which has not yet been elucidated, and which may be parasitic fungi of the mosquito.

A brief history of how these facts came to be ascertained may be of interest. Laveran discovered the human parasites in 1880; and Danilewsky those of birds, some years later. Golgi established the law of endogenous reproduction by means of spores in 1885; and noted the differences in the various human species. Later, several Italian writers observed the distinction between the sporocytes and the gametocytes, but failed to understand the nature and object of these latter forms. The escape of the microgametes can be witnessed *in vitro;* and a dispute now arose as to the meaning of these bodies. Antolisei, Grassi, Bignami, Labbé and others held that they are products of death and degeneration *in vitro.* On the other hand, Laveran, Danilewsky and Mannaberg supposed them to represent the highest development of the organisms, while the last writer thought that they were meant for an exogenous saprophytic existence—without, however, suggesting the mode of their escape. In 1894 Manson concluded that the gametocytes are intended to continue the species outside the vertebrate host; and that they escape into the stomach of a suctorial insect, and then give rise to flagellulæ—as he considered the microgametes to be—which in turn develop in the tissues of the insect. He founded these views chiefly on the fact that the microgametes escape from the gametocyte only after abstraction of the blood from the vertebrate host. Laveran had already surmised that the mosquito is the alternative host of the human parasites; and Manson now claimed the mosquito as the suctorial insect referred to.

Early in 1895 I attacked the subject experimentally in India, on the lines laid down by Manson. Owing to the difficulty of the investigation and to the use of wrong species of mosquitoes, I failed for more than two years in reaching positive results. In August 1897, however, on employing two species of Anopheles fed on patients containing the crescentic gametocytes, I found the zygotes in various stages of growth attached to the wall of the insect's stomach. My work was now interrupted; but next year I succeeded in following out the life-history of the zygotes of one of the parasites of birds in their development in *Culex pipiens.* The zygotoblasts were found in the salivary glands of the mosquitoes; and lastly, in July 1898, I succeeded in infecting a large number of healthy birds by the bites of infected insects.

Meanwhile (1898) MacCallum had discovered the true nature of the microgametes by actually witnessing the sexual act *in vitro,* while Metchnikoff, and Simond had found microgamates also in *Coccidium oviforme* and *C. salimandrae;* so that the exact relationship between the gametocytes in the blood of the vertebrate (intermediary) hosts and the zygotes found by me in the mosquitoes (definitive hosts) became quite evident.

My results were published by Manson in August 1898, and were confirmed by Daniels, of the Malaria Commission of the Royal Society, in December. It was now easy to extend my observations to other species of the group, a work, however, which I was unable to undertake. In November and December 1898, Grassi, Bignami and Bastianelli cultivated two of the human parasites in a third species of Anopheles, *A. claviger,* Fabr., and succeeded in infecting several healthy persons. Shortly

afterwards Koch confirmed the principal observations which had been made.

If we can exterminate the malaria-bearing species of mosquito in a locality, we may expect to prevent the propagation of the parasites there; I trust, therefore, that these investigations will not remain without practical results.

It may be useful to add a note regarding the somewhat confused matter of the classification and nomenclature of the various species. I divide those of men and birds into two genera, named as follows:—

Family: HÆMAMŒBIDÆ, Wasielewski.

Genus I. *Haemamoeba*, Grassi and Feletti. *The mature gametocytes are similar in form to the mature sporocytes before the spores have been differentiated.*

Species 1: *Haemamoeba Danilewskii*, Grassi and Feletti. Syn.: *Laverania Danilewskii*, Grassi and Feletti, in part; *Halteridium Danilewskii*, Labbé; &c. Several varieties—possibly distinct species. Parasite of pigeons, jays, crows, &c.

Species 2: *Haemamoeba relicta*, Grassi and Feletti. Syn.: *Haemamoeba relicta* + *H. subpraecox* + *H. subimmaculata*, Grassi and Feletti; *Proteosoma Grassii*, Labbé; &c. Parasite of sparrows, larks, &c.

Species 3: *Haemamoeba malariae*, Grassi and Feletti. Syn.: *Haemamoeba Laverani*, Labbé, in part. Parasite of quartan fever of man.

Species 4: *Haemamoeba vivax*, Grassi and Feletti. Syn.: *Haemamoeba Laverani*, Labbé, in part. Parasite of tertian fever of man.

Genus II: *Haemomenas*, gen. nov. Syn.: *Laverania*, in part + *Haemamoeba*, in part, Grassi and Feletti. *The gametocytes have a special crescentic form.*

Species: *Haemomenas praecox*, Grassi and Feletti. Syn.: *Haemamoeba praecox* + *H. immaculata* + *Laverania malariae*, Grassi and Feletti; *Haemamoeba Laverani*, Labbé, in part; &c. Several varieties—possibly distinct species. Parasite of the irregular, remittent, pernicious or æstivo-autumnal fever of man.

The two species lately discovered by Dionisi in bats appear to belong, one to one genus, and the other to the other genus. Two species described in frogs do not contain pigment, and require further study. Grassi and Feletti's arrangement is very confused, chiefly on account of their combining *H. Danilewskii* with the crescentic gametocytes of *H. praecox* in a separate genus, *Laverania*. Labbé admits only one human species, and yet erects two genera for the avian species. The double spore-clusters of *H. Danilewskii*, on which he lays much stress, are not always found, and are at the best due, I think, merely to the presence of the nucleus compressing so large a parasite. There is little to justify generic differences between the four species of *Haemamoeba*. On the other hand, the last species given above is sharply divided from the rest.

The zygotes of three species have been found to develop in mosquitoes as follows:—

*Haemamoeba relicta* in *Culex pipiens*.

*Haemamoeba vivax* in *Anopheles claviger*.

*Haemomenas praecox* in two undetermined species of Anopheles in India, and in *Anopheles claviger* in Italy.

The development is the same in all, but slight differences in details have been noticed between *H. vivax* and *H. falcipara* in the mosquito.

The terminology employed above has been adopted in consultation with Prof. Herdman, F.R.S. Some of it has already been used in this connection by Mesnil, and by Grassi and Dionisi. Nuttall has recently given a very full account of the subject in the *Centralblatt für Bakteriologie*.

RONALD ROSS.

## SCIENCE AND EDUCATION.

TWENTY years have passed since Huxley said, at the opening of Mason College, Birmingham: "How often have we not been told that the study of physical science is incompetent to confer culture; that it touches none of the higher problems of life; and what is worse, that the continual devotion to scientific studies tends to generate a narrow and bigoted belief in the applicability of scientific methods to the search after truth of all kinds? How frequently one has reason to observe that no reply to a troublesome argument tells so well as calling its author a 'mere scientific specialist.' And, I am afraid it is not permissible to speak of this form of opposition to scientific education in the past tense." . . .

The exact applicability of these words in this year of grace is as good an example of the slowness of progress as could be wished. It is still urged almost as persistently as ever, and with the weight of university authority, that the only avenue to culture is by way of classics and the humanities. Has nothing come of the example of men like Huxley, Darwin, and the host of other widely-read, and deeply-educated, students of nature who, having borne their testimony, have gone over to the great majority?

These thoughts follow naturally from recent events in connection with the discussions and suggestions anent the constitution of the proposed Board of Education. The retirement of Sir John Donnelly from the secretaryship of the Science and Art Department led to the appointment of Sir George Kekewich to the vacant position, and for the future he will rule educational affairs both at South Kensington and Whitehall. In addition, two principal assistant secretaries were appointed, one for each of the departments referred to. These arrangements have disturbed the minds of the champions of that ill-defined section of educational work known as secondary education. After due representations Sir John Gorst stated, in the House of Commons, in reply to a question of Prof. Jebb, that a third official will be later appointed as assistant secretary for secondary education. This decision resulted in a correspondence which has brought to mind Huxley's addresses on education.

When a distinguished scholar and, on most subjects, broad-minded thinker, as Sir William Anson is, expresses himself in words like the following, which are taken from a letter in the *Times* of July 27, some sort of protest seems absolutely necessary.

"The attitude of those who are interested in secondary education, properly so-called, as distinct from elementary education on the one hand and instruction in science and art or technical education on the other."

"Scientific teaching alone will not produce the educated man, and the scientific expert may not be the best judge of the value of literary and historical studies, or of the respective parts which science and the humanities should play, even in an education which is mainly scientific."

"It is very important if the educational forces are to be brought into line, if the youth of the country are not merely to acquire some useful knowledge, but to become educated men—that where secondary education is given at all it should be given well, and that wherever it is given some one should watch over its interests and see that in the competition of humane and technical studies a due proportion is observed."

A number of unjustifiable conclusions may be derived from this letter; and it is therefore worth while to deal with a few of the points in it.

In the first place, it is tacitly assumed that some kind of secondary education exists in which instruction neither in science nor in art is given. The synonymous use of technical education and instruction in science and art must be passed over, though it provides a suggestive

index to the views of persons who are ever ready to pass judgment upon the educating capabilities of science and art. A course of instruction which ignores science and gives the cold shoulder to art is in one sense "secondary," but in no respect can it be called education. "Secondary education, properly so called," cannot exist distinct from "instruction in science and art." In fact, it is a little difficult to imagine what meaning Sir William Anson is intending to express. It would seem that he wishes to draw a distinction between the education offered in institutions of the grammar school type and those in which the curricula are at present directly governed by the Department of Science and Art. But it is a noteworthy circumstance that quite a number of old grammar schools provide, side by side with their classical work, classes in science which are actually subsidised by the much maligned department at South Kensington. And what is even more strange, judged from the point of view of Sir William Anson's letter, quite a number of these old grammar schools are also what is technically called "organised schools of science," which being interpreted, means that their time tables are modelled upon the regulations laid down in the Science and Art Directory, since they must be approved by the Inspector of the Department.

But the inference of the second quotation is of a more perverted type. "Scientific teaching alone will not produce the educated man," &c. Here again, something different from what is actually said is meant. Of course, Sir William Anson would agree that no teaching which is not scientific will do much towards educating anybody. As he himself said in a debate in the House of Commons on June 26, teachers should be taught how to teach, that is, should have "scientific" teaching explained to them. What is doubtless meant in the *Times* letter is, that instruction in natural science alone will not produce the educated man.

With this statement every man of science will agree; but neither will instruction in any single branch of human knowledge by itself educate. It would be just about as wise to attempt to educate a boy without introducing him to the beauties of our own incomparable national literature or that of some other great country, as it would to attempt to make him a cultured man and at the same time keep him ignorant of his place in the scheme of the universe and of the grandeur and beauty of the laws which govern things material. Culture is not the narrow business which the products of an exclusively classical training would have the world believe. Those authorities who claim for themselves alone the positions of priests in the temple of culture, are anachronisms—they should have lived in the Middle Ages. No education is worthy of the name which fails to endow its possessor with a sufficient breadth of view to give him a charitable demeanour towards every department of mental activity, and most of all to that wonderful accumulation of scientific knowledge to which we owe all that is best in life at the end of the nineteenth century. The man of science is as devout an admirer of literature, whether classical or modern, as any man. He is as ready with a profound admiration for the unique creations of the highest art, whether pictorial, musical, dramatic or what not, as any man. But he does claim that his goddess, science, is as worthy of attention as any other, and he has a right to expect that the reverence which he willingly extends to other deities shall similarly be shown by those who approach his particular shrine.

"The scientific expert may not be the best judge of the value of literary and historical studies or of the respective parts which science and the humanities should play, even in an education which is mainly scientific." So writes Sir William Anson. Possibly not, is the natural answer. But it is just as true that the classical (or historical) expert may not be the best judge of the value of scientific and artistic studies, or of the respective parts which the humanities and science should play, even in an education which is mainly classical. This is only a verbose way of saying that no individual can know everything. There is just as good reason, to say nothing stronger, for giving the control of the classical part of secondary education into the hands of a widely cultured and eminent man of science as there is for making a similarly great classical authority responsible for the government of the teaching of science or art. We surmise that no good will come of special pleading of this specious kind.

With the third quotation from Sir William Anson's letter given above there can be no disagreement if it is rightly understood. No man of science would imagine the youth of the country to be educated who had merely acquired some useful knowledge. We all want our secondary education to be given well. But let us look facts in the face. It is possible to spend twenty years in studying classics and to remain uneducated. We may become familiar with the histories of all the nations of the earth and be as far from culture as when we started the study. The secrets of nature may all have been laid bare before our understanding eyes, and yet we may still dwell with the Philistines. Let it be thoroughly understood that education and culture are greater than history, greater than classics, greater than science, but include them all, each in its proper place, and these narrow-minded bickerings as to the place of this or that subject of study will become things unknown.

One more reference to Huxley will define the scope of education from the point of view of a representative man of science. Speaking in 1868 to the working men of South London, Huxley defined the well-educated man: "That man, I think, has had a liberal education who has been so trained in youth that his body is the ready servant of his will, and does with ease and pleasure all the work that, as a mechanism, it is capable of; whose intellect is a clear, cold, logic engine, with all its parts of equal strength, and in smooth working order; ready, like a steam engine, to be turned to any kind of work, and spin the gossamers as well as forge the anchors of the mind; whose mind is stored with a knowledge of the great and fundamental truths of Nature and of the laws of her operations; one who, no stunted ascetic, is full of life and fire, but whose passions are trained to come to heel by a vigorous will, the servant of a tender conscience; who has learned to love all beauty, whether of Nature or of art, to hate all vileness, and to respect others as himself."

## *THE UNIVERSITY OF LONDON.*

THE supplementary vote of 65,000*l.* required in connection with the housing of the University of London in the Imperial Institute building at South Kensington was agreed to by the House of Commons on Monday.

A portion of the western end of the building is to be assigned to the Institute free of rent, and the eastern and central portion of the building will form the new home of the London University. The space which will be given to the University in the building will be far greater than was now enjoyed by that body. In consideration for the transfer of the lease to the Office of Works, the Government will provide funds sufficient to pay off the existing mortgage of 40,000*l.* and discharge the floating debt of 15,000*l.* In addition to the cost of structural alterations, estimated at 7000*l.*, the vote included 3000*l.* for the maintenance and repair of the buildings and for the purchase of the necessary furniture.

The Treasury Minute, dated July 13, containing particulars of the transfer, is reprinted below:—

The First Lord and the Chancellor of the Exchequer recall the attention of the Board to the question of the future housing of the University of London in the present Imperial Institute buildings, and they refer to the Board's Minute of February 16 last.

In pursuance of that Minute, conferences have been held between representatives of the University, of the Institute and of Her Majesty's Government, which have resulted in definite arrangements, subject only to adjustment on points of detail. The report of the Government representatives is now before the Board together with correspondence and memoranda connected with the subject.

Before proceeding to state the conclusions as affecting the University, the First Lord and Chancellor of the Exchequer desire to refer in general terms to the arrangements which have been made by Her Majesty's Government with the governing body of the Institute respecting the whole group of buildings now in their possession.

They are as follows :—

(1) The lease under which the buildings are held from the Commissioners for the Exhibition of 1851 will be transferred to the Commissioners of Works as representing the Crown, and the latter Commission will thereupon become responsible for maintenance, rates, custody and protection of the buildings. The Commissioners for the Exhibition of 1851 have assented to this arrangement.

(2) An agreed portion of the buildings will be assigned for the use of the Institute, free of rent, but with the responsibility for internal maintenance and repairs of that portion.

(3) The cost of removing the Institute from the portions of the buildings which they will surrender, including the necessary structural alterations, will be paid by Government.

(4) In consideration of the transfer of the lease, Government will provide funds sufficient to pay off the existing mortgage of 40,000*l.* on the building, and also to discharge a floating debt of the Institute, not to exceed in all 15,000*l.*

These arrangements will enable Her Majesty's Government to offer to the London University accommodation in the building which may roughly be described as follows :—

The eastern and central portions of the main block, including the principal entrance, vestibule and staircase, and the Great Hall; subject to occasional use by the Institute of certain portions of the central block when not required by the University, under regulations approved by the Chancellor of the University, and subject also to certain reservations in favour of the Government of India.

Also a portion of the upper floor of the inner block of building running east and west; and the temporary structure now standing in the South-Eastern Court.

This offer, which provides much more space than the present building in Burlington Gardens, has been accepted by the Senate of the University.

The principal structural alterations and adaptations required are—

(*a*) For the University—the provision of suitable lavatories and refreshment accommodation for candidates, and, if desired, the construction of a separate staircase giving access for candidates to examination rooms on the upper floors :

(*b*) For the Institute—the construction of a new entrance at the western end of the main block, the provision of new library and dining accommodation for Fellows, and the redecoration of rooms to which some of the services (Colonial and Indian) now provided in the eastern portion of the building will be transferred.

The University will occupy its new quarters under conditions substantially the same as those under which it now occupies the building in Burlington Gardens.

As regards accommodation for the practical examinations of the University in physics and chemistry, it has been agreed that this shall be provided in the new buildings about to be erected for the Royal College of Science, subject to arrangement between the two bodies as to dates of user. The Science and Art Department will take charge of, and keep in order, the instruments and appliances for the examinations.

The formal transfer of the lease will be carried into effect by the Solicitor to this Board; and the First Commissioner of Works should report at once as to the cost of the necessary works, as to arrangements for custody of the building, and as to the terms upon which the Institute should become tenants of the part of the building to be assigned to them.

The formal concurrence of the University and of the Institute, subject to settlement of details, has been obtained.

My Lords concur. They take note of the statements of the First Lord and Chancellor of the Exchequer, and desire that the necessary steps may be taken for carrying them into effect.

## *NOTES.*

THE seventy-first meeting of German Naturalists and Physicians will be held at Munich on September 17–23. According to the final programme of arrangements, the two general meetings will be held in the Königliche Hoftheater. At the opening meeting, on Monday, September 18, the following lectures will be delivered :—Dr. Nansen, on his journey towards the North Pole, and its results; Prof. v. Bergmann, Berlin, on the use of radiography to surgery; and Prof. Förster, Berlin, on the progress of astronomical thought during the past hundred years. At the second general meeting, on Friday, September 22, Prof. Birch-Hirschfeld, Leipzig, will lecture on science in relation to medicine; Prof. Boltzmann, Vienna, on the development of the methods of theoretical physics in modern times; and Prof. Klemperer, Berlin, on Liebig and medicine. There will be thirty-seven sections for scientific papers, seventeen being devoted to purely scientific subjects, and twenty to medicine. In a general meeting of the scientific sections Prof. Chun, Leipzig, will give an account of the results of the German Deep Sea expedition. A report will be presented by Prof. Bauschinger (Berlin), Prof. Mehmke (Stuttgart), and Prof. Schülke (Osterode) on the question of the decimal division of time and angle—a subject which will also be dealt with in a congress to be held in connection with the Paris Exposition next year. In a general meeting of the medical sections, Prof. Marchand (Marburg) and Prof. Rabl (Prague) will report upon the relation of pathological anatomy and general pathology to embryology, with special reference to the cell theory.

HITHERTO the overhead system of conveying electrical energy for driving tramcars has been the one most commonly adopted. The London County Council has, however, just decided to test underground systems of electric traction upon one of their lines. The recommendation of the Highways Committee, adopted on Tuesday, is as follows :—"That the estimate submitted by the Finance Committee for 10,000*l.* be approved; and that the Council do authorise the expenditure by the Highways Committee of that sum for the preparation of plans, specifications, and estimates, and other preliminary expenses, in connection with the reconstruction, for the experimental use of underground systems of electrical traction, of that part of the London County Council tramways between Westminster Bridge and Tooting; and that the committee be authorised to make all necessary arrangements for the purpose above referred to."

THE Duke of Bedford has been elected by the Council President of the Zoological Society of London, to fill the vacancy caused by the death of the late Sir William Flower.

UPON the recommendation of the Governor-General of India in Council, Her Majesty's Government has conferred upon Surgeon-General Sir J. Fayrer, Bart., K.C.S.I., Indian Medical Service, as a reward for distinguished and meritorious service, a good service pension of 100*l.* per annum.

THE Welby Prize of 50*l.*, offered for an essay on "The causes of the present obscurity and confusion in psychological and philosophical terminology, and the directions in which we may hope for efficient practical remedy," has been gained by Dr. Ferdinand Tönnies, whose essay, translated by Mrs. B. Bosanquet, appears in the current number of *Mind*.

PROF. GUIDO CORA, of Rome, has been elected (by Royal decree) a member of the Upper Council of the Geodetical Works of Italy (Consiglio Superiore dei Lavori Geodetici dello Stato).

THE expedition from the Liverpool School of Tropical Diseases, to which reference has already been made (p. 278), left the Mersey on Saturday in the steamer *Fantee*. Freetown will be the centre of experiments, with special regard to Major Ross's theory as to malaria being propagated by mosquitoes.

THE medical authorities of the Owens College and of the Royal Infirmary, Manchester, have been asked by the Chamber of Commerce to consider the advisability of forming a Manchester committee to co-operate with the Liverpool committee in the establishment and support of the Liverpool School for the study of tropical diseases.

THE annual congress of the British Medical Association was opened at Portsmouth on Tuesday. The president, Dr. Ward Cousins, delivered an address in which he sketched the progress made during the present century in medicine and surgery, with particular reference to recent discoveries in pathology and biology.

THE detailed programme of arrangements for the reunion of the Institution of Electrical Engineers in Switzerland, to be held in Switzerland from September 1 to September 9, has now been issued. The Council have decided that, with the exception of candidates for election, only members (of all classes in the Institution), and ladies and children accompanying them, can be authorised to take part. A number of visits to works and manufactories, and excursions to places of interest, have been arranged, and the programme provides opportunity for members f the Institution to spend a pleasant week in Switzerland.

THE sixth International Agricultural Congress will be held from July 1-8, 1900, in connection with the Paris Universal Exhibition of next year. The work of the congress will be divided into seven sections, as follows: (1) rural economy (agricultural credit, agricultural associations, land surveying, agrarian questions); (2) agricultural education (experimental stations, field experiments, &c.); (3) agricultural science (application of science to agriculture, agricultural improvements); (4) live stock; (5) practical agriculture (industrial crops and agricultural industries); (6) special crops of the South (silk production, early fruits and vegetables, perfume plants and colonial productions); (7) injurious insects and parasites (international measures for the protection of useful animals). Copies of the detailed programme may be obtained on application to the English representative of the International Agricultural Commission, Sir Ernest Clarke, at 13 Hanover Square, London, W.

THE Baly Gold Medal of the Royal College of Physicians of London, instituted in 1866 by Dr. F. D. Dyster, of Tenby, "in memoriam Gulielmi Baly, M.D.," which is awarded every alternate year on the recommendation of the president and council to the person who shall be deemed to have most distinguished himself in the science of physiology, especially during the two years immediately preceding the award, has been awarded to Dr. C. S. Sherrington, F.R.S., Professor of Physiology in University College, Liverpool.—The report of the Laboratories Committee of the College states that, since March 10 last, 1100 doses of antitoxin, each containing 2000 units, and 4425 doses, each containing 4000 units, for the treatment of diphtheria in the hospitals of the Metropolitan Asylums Board have been supplied and all the demands fully met. During this period 19,900,000 units have been supplied. During the same period five doses of 4000 units each have been supplied to the medical officers of health according to instructions received from the Metropolitan Asylums Board. Under the grant from the Goldsmiths' Company 459 doses of antitoxin containing 1,134,000 units have been supplied to the general an children's hospitals in or near London.—Dr. Arthur Foxwell, of Birmingham, will deliver the Bradshaw Lecture of the College on November 2. Dr. P. Horton Smith has been appointed Goulstonian Lecturer, and Dr. W. B. Cheadle Lumleian Lecturer for 1900, and Prof. W. D. Halliburton the Croonian Lecturer for 1901.

THE death is announced of Prof. Balbiani, professor of comparative embryology in the Collège de France.

THE expedition organised by the Peary Club, of New York, for the relief of Lieut. Peary in the Arctic regions started a few days ago. Prof. William Libbey, of Princeton University, is chief of the expedition, and with him are Prof. W. F. McClure, Dr. Arnold E. Ortman, Mr. Charles F. Silvester, and two representatives of the United States Coast Survey. The first object of the expedition is to take provisions and other supplies to Lieut. Peary. After the stores have been unloaded from the *Diana*, the return trip will be converted into a tour for scientific explorations. Chiefly deep sea investigations will be carried on, and specially prepared dredging apparatus have been provided for this purpose. It is expected that the party will return about October 1.

THE Bill having for its object the sanitary regulation of oyster beds has been withdrawn. When the order for the Committee stage of the Bill came before the House of Lords on Monday, Lord Harris said he had to move that the order be discharged. The intention of the Local Government Board in introducing the Bill was to protect as far as possible the public health from attack from diseased oysters; and the Board therefore selected as the local authorities by which the Bill was to be put into operation the councils of counties and boroughs which were concerned with the sanitary matters of their districts. But the Select Committee to whom the Bill was referred after the second reading decided that this was a matter which concerned more the health of the oyster than the health of the human being; and on a division they substituted the Local District Fisheries Committee, which looked after the well-being of fish for the councils of counties which were concerned with the public health as the authority in the Bill. But the Board of Trade, to whom the Bill was referred, decided that the change rendered the Bill impracticable; and in the circumstances the President of the Local Government Board does not intend to proceed further with the measure. The Bill was therefore withdrawn.

AT the meeting of the Institution of Mechanical Engineers held at Plymouth last week, a paper of much historic interest was read by Sir Frederick Bramwell, the subject being the South Devon atmospheric railway, preceded by remarks upon the transmission of energy by a partially rarefied atmosphere. Leaving out of consideration Savery's and such like machines for the raising of water by means of a partial vacuum produced by the condensation of steam, the first suggestion for transmitting energy by the rarefaction of air appears to have been made by Denis Papin in 1695. The matter lay in abeyance for more than a century, and then Mr. G. Medhurst proposed the propulsion of trains within a tube by means of air pressure. In 1824 John Vallance took out his patent, so very well known to all who have interested themselves in this subject of transmission of energy by the pressure of the atmosphere. Excep that Vallance proposed to move his train by the rarefaction of the air, his scheme was a mere repetition of that of Medhurst already mentioned. But the man who really developed this

mode of transmission of energy was John Hague. In addition to using a partial exhaust system to work cranes and tilt hammers, Hague applied this mode of transmitting energy to driving the machinery of powder mills, so as to remove the danger of steam-engine fire to any distance needed for safety. He also applied it to work the individual cutting-out presses and coining presses of a mint which he constructed for Rio Janeiro.

VALLANCE'S (Medhurst's) system of atmospheric railway was put to work in 1861, in the case of the "Pneumatic Postal Despatch," which was, in that year, laid down experimentally in Battersea Fields. In 1863 a line on this system was laid and got to work from Euston to the Holborn Post Office, a distance of about one and half miles, with the intention of going forward another mile to the General Post Office. In this case the ◠-shaped tube was as much as 4 feet high by 5 feet wide. The trains were "blown" and "sucked" backwards and forwards. A vacuous, or a pressure, condition of a few inches of water was found sufficient for the propulsion. In 1844, Mr. Brunel recommended the atmospheric system for the South Devon Railway, and by 1846 it was actually laid down nearly the whole way from Exeter to Newton. Four atmospheric trains ran on the line each way daily in 1847. In the life of Brunel, it is stated that 865 horse-power were required to do the work that he had a right to expect would have been done by 300 horse-power. By August 1848 the valve had begun to fail throughout its length. The cost had been 1160*l*. per mile, and in August 1848, just four years after Brunel had advised the trial of the atmospheric system, he reported that he did not recommend its extension, and, in fact, suggested it only as an assistant on inclines. The directors then suspended operations, and, afterwards, locomotives were used throughout.

SEVERAL popular articles on scientific subjects appear in the current number of the *Century Magazine*. Of particular interest are two articles on tornadoes, one by Mr. John R. Musick giving a description of a tornado witnessed by him at Kirksville, Missouri, in April of this year, and another by Prof. Cleveland Abbe on tornadoes in general. Mr. Musick's testimony as to the effects of the tornado is most astonishing. He says that when the storm struck the city, "doors, shutters, roofs, and even whole houses were sent soaring and whirling to a height of three or four hundred feet. I saw the wheel of a wagon or carriage and the bodies of two persons flying up into the storm-cloud. One house was lifted upwards to a height of over one hundred feet, when it seemed to explode into a thousand fragments, which went soaring, whirling and mingling with the other débris." Perhaps the most remarkable experiences were those of three persons who were caught up in the storm, and after being carried nearly a quarter of a mile, were let down so gently that none was killed. Several horses and many other animals were taken up by the storm and carried to considerable distances. One horse was carried two miles by the storm and alighted uninjured. An orchard south of the city had the trees torn up by the roots, carried four or five hundred yards, and piled into some vacant fields. An idea as to the fury of the wind may be formed by the size of the trees uprooted. Some of these were from twelve to eighteen inches in diameter, with roots ten feet in length The earth from which they had been jerked is said to have looked as if it had been torn by dynamite explosions.

As to the origin of tornadoes, Prof. Cleveland Abbe remarks that the point about which there has, perhaps, been the most uncertainty relates to the rotatory motion of the wind at the centre of the path of destruction. From the information he has been able to gather it appears that generally a west or north-west wind is blowing over the country, with a front of many miles in length, which trends south-west and north-east. This cool north-west wind pushes aside a gentler southerly wind that had been prevailing over that same region during the previous twenty-four hours. In the long belt, or trough, where these two winds meet, the warmer southerly wind is suddenly elevated and cooled by expansion, as also by mixture with the under-current of cold north-west wind. A cloud is thus formed, or in fact rolls of clouds, along the whole front of the area of north-west wind. At certain favourable spots the cloud soon becomes so large as to form a special indraft upwards through its centre, and the ascending wind must necessarily acquire a spiral ascending movement. The direction of rotation in this spiral is almost invariably the same as that of the hurricanes of the Atlantic Ocean, or the general storms attending the areas of low pressure that move eastwards over the United States, namely counter-clockwise.

THE Report of the U.S. Weather Bureau for the year ending June 1898 shows that no time has been lost in developing the Meteorological Service of the West Indies; arrangements have been made for observations being cabled twice daily from several islands to Kingston (Jamaica) and the central office in Washington, and negotiations are being carried on with the French authorities for the co-operation of the observers in Martinique. The maintenance of observations at Havana during the period of hostilities with Spain is also very gratifying. The important work of producing a thoroughly satisfactory kite has seriously occupied the attention of the Weather Bureau; sixteen stations have now been completely equipped, and the observers have all received a course of instruction in Washington. The observations hitherto made in the exploration of the upper air by this means contain much information that is new and of practical importance, independently of their value in making weather forecasts. The Canadian Meteorological Service has established a continuous record of the oscillations of the waves of Lake Ontario, which seem to show a connection with atmospheric conditions. These oscilliations are of much interest from several points of view, and the subject is engaging the attention of the U.S. Weather Bureau.

THE second annual report of the Council of the Röntgen Society shows that steady progress is being made. The Society numbers 148 ordinary members and five honorary members. Fresh evidence is continually received of the value of Röntgen rays in surgery, and there is much useful work open to the Society in the way of stimulating improvements in apparatus and in methods of investigation. The Council announce that Mr. William Noble has consented to be nominated as president for the ensuing year. He was among the earliest workers with X-rays, and has done useful service in radiography and on the physical side of the subject which it is the Society's object to advance.

THE volume of *Sitzungsberichte* of the Royal Bohemian Academy for 1898 contains, amongst other communications, a number of mathematical papers. These include notes on theory of curves, by C. Küpper (Prag); on a property of factorials, and remarks on trigonometric series with positive coefficients, by M. Lerch (Freiburg); on the residues of functions defined by differential equations of higher order, and on a system of semi-curvilinear coordinates, by Michel Petrovitch (Belgrade); on the infinitesimal geometry of certain plane curves, by J. Sobotka (Vienna); a note on spherical harmonics, by Franz Rogel (Barmen); and on the principal propositions of stereographic projection regarded as corollaries of Quetelet and Dandelin's theorem, by Carl Pelz (Prague).

FROM Messrs. Williams and Norgate we have received a copy of the *Sitzungsberichte und Abhandlungen* of the "Isis" Society, of Dresden, for 1898. It contains a paper, by W. Hallwachs, on determinations of the refractive indices of solutions.

In it the author gives an account of his differential method with grazing incidence, for which a double-trough refractometer has been used. The process in question has been applied to solutions of brome-cadmium, sugar, di- and tri-chloracetic acid and their potassium salts; and the author investigates the relation between the refractive index and the degree of concentration with a view of determining whether this is influenced to any extent by dissociation. The experiments show that such an influence, if it exists, is too small to be measurable with exactitude. This result is at variance in the case of bromecadmium with those obtained by Le Blanc and Rohland, but the discrepancy is attributed to an error.

THE twenty-first of the series of electrical papers published by W. G. Hankel in the *Abhandlungen der k. Sächs. Gesellschaft der Wissenschaften* deals with the thermo-electric and piezoelectric properties of certain crystals, including, amongst others, the formates of barium, lead, strontium and calcium, nitrates of barium and lead and sulphate of potassium. It is illustrated by several diagrams showing the distribution of positive and negative electrification over the faces of the several crystals.

THE general results of the magnetic survey of Sicily and the adjoining islands, commenced in 1890 by Prof. Chistoni and Signor L. Palazzo, were recapitulated in a communication by the latter observer to the *Atti dei Lincei*, vi. (2) 11. In *Terrestrial Magnetism* for June 1899, Signor Palazzo now gives a magnetic chart of Sicily showing the course of the isogonal and isoclinal lines, and the isodynamical lines for the horizontal component. The remarkable deviations produced in these curves by volcanic areas are well shown. Signor Palazzo having been appointed as a delegate at the International Magnetic Conference held in connection with the Bristol meeting of the British Association last year, availed himself of the opportunity for instituting a comparison between the magnetic instruments of the Italian Central Meteorological Office and those of Parc Saint-Maur and Kew. The results of this comparison have been published in the *Atti dei Lincei*, viii. (1) 8 and 9, and the author considers that these comparisons fully establish the trustworthiness of the Italian instruments and methods.

FOLLOWING in the footsteps of Japan and France, which countries in 1894 despatched scientific experts to investigate the outbreak of plague in Hong Kong, Germany decided in the year 1897 to send out a commission to study the plague in India, and in February of that year Dr. Gaffky, Dr. Pfeiffer, Dr. Stricker, and Dr. Dieudonné arrived in Bombay. The results of their labours have just been published in a volume of the *Arbeiten aus dem Kaiserlichen Gesundheitsamt*, and covers no less than 356 large quarto pages, whilst copious illustrations, coloured and otherwise, beautifully executed, serve to elucidate the text. The literature of previous outbreaks of plague in India has been carefully summarised by the authors, and the history of the recent severe epidemic has been traced as accurately as possible. As was to be anticipated, a large portion of the report describes the numerous experimental investigations undertaken by the experts, and the results of these researches form a valuable addition to the already bulky records obtained during previous inquiries. Prominence is given to the encouraging results obtained by Haffkine's method of preventive inoculation, and in this connection mention must be made of an official report recently published in India of inoculations against plague made from May to September last year in Hubli. The actual number of inoculations carried out by Surgeon-Captain Leumann and his staff amounted to some 78,000 altogether, and in summarising the results of his extended experience, Captain Leumann remarks that "inoculation arranges itself by the protection it affords in the foremost rank of methods for dealing with this disease."

AN article on "The Ethics of Vivisection," which appears in the current number of the *Edinburgh Review*, ought to be reprinted and widely distributed as a plain and dignified statement of fact as to the purpose of physiological research and the actual conditions under which it is carried on. So many misleading leaflets and tracts have been published by opponents of experimental work in physiology that all persons desirous of arriving at the truth of the matter should give consideration to the side or the case presented in the article to which reference has been made. In the course of the article the pain deliberately inflicte upon animals for mercenary motives, for sport, for food, for ornament, and other purposes is mentioned, and the very apt remark is made that "the only form of vivisection to which he [an opponent of vivisection] objects is that which furnishes not luxury, amusement, or vanity, but knowledge." But this only meets objections with a *Tu quoque*, and a specific statement of what civilised man owes to experimental physiology is more convincing to the logical mind. Such a statement is given in the article.

REFERRING to the results of the application of the experimental method advocated by Bacon and Harvey, the writer in the *Edinburgh Review* points out that physiologists and biologists "have enriched practical surgery with antiseptic methods and with anæsthesia; with control over hæmorrhage while operating; with a rational and successful treatment of aneurism and of glaucoma; with the power in not a few cases of removing a tumour even from the brain itself. In medicine proper, all that is summed up in the phrase 'heart disease,' all knowledge of arterial tension and its influence on the whole organism, have all been evolved gradually from the basis of Harvey's discovery. All our knowledge of nervous disease is based upon vivisectional experiments, from Charles Bell to Hitzig and Ferrier. Almost all our knowledge of the digestive processes, of angina pectoris and of methods of relieving it, has been gained through experiment. Practical medicine has been enriched through experimental research with such drugs as digitalis, cocaine, croton-chloral, nitrite of amyl; with the method of auscultation; with a knowledge of the cause of tuberculosis, typhoid fever, cholera; with the life-history of parasites; with the cause of myxœdema and related conditions and how to relieve them, and with a life-saving remedy for diphtheria. . . . It is, in fact, no figure of speech, but the simplest of truths, to say that everything of solid value in medicine and surgery is based upon knowledge gained by the experimental method." With this quotation we leave the article, convinced that it will be of much assistance in the spread of truth and the advancement of science.

A SHORT article, illustrated by reproductions from photographs, on the Medanos, or moving sand-hills of the Peruvian desert, is contributed to *Pearson's Magazine* by Mr. George Griffith.

THE following official botanical publications have reached us from the United States:—Sugar as food, by Mary H. Abel (U.S. Department of Agriculture, *Farmers' Bulletin*, No. 93); Mushrooms, II., by Prof. G. F. Atkinson (Cornell Univ. Agricultural Experiment Station, *Bulletin* No. 108); Notes from the South Haven sub-station; Vegetable tests for 1898; Bush fruits for 1898; Combating disease-producing germs; Killing the tubercle bacillus in milk (Michigan State Agricultural College Experiment Station (*Bulletins* Nos. 169-173).

THE *Journal of Applied Microscopy* continues, in the numbers most recently received (May-July), its useful *résumé* of recent work on microscopical technique:—Methods of plant histology,

by Prof. C. J. Chamberlain; Current bacteriological literature, by Prof. H. H. Waite; Normal and pathological histology, by Dr. R. M. Pearce; Neurological literature, by Edith M. Brace. Among original communications in the same branch of science we may mention an improvement in the technique of making blood-serum culture media, by Ernest C. Levy; and preparing sections of cochlea for microscopical examination, by M. T. Cook and H. H. Zimmermann.

Two new volumes have been added to the series of brochures published by MM. Georges Carré and C. Naud under the general title of "Scientia." The volumes are: "Les actions moléculaires dans l'organisme," by Prof. H. Bordier, and "La coagulation du sang," by Prof. Maurice Arthus. Each book comprises about one hundred pages, and shows the present state of knowledge of the subject dealt with in it.

The seventh volume of the renowned "System of Medicine," edited by Prof. Clifford Allbutt, F.R.S., has been published by Messrs. Macmillan and Co., Ltd. The volume continues the treatment of the subject of diseases of the nervous system. In the eighth volume, which will conclude the work, this subject will be completed, and the full sections on mental diseases and diseases of the skin will be added. When the final volume has appeared, it will be reviewed with others not yet noticed in these columns.

The additions to the Zoological Society's Gardens during the past week include a Purple-faced Monkey (*Semnopithecus cephalopterus*, ♂) from Ceylon, presented by Mrs. Usborne; a Common Badger (*Meles taxus*, ♀), British, presented by Mrs. F. Travers; a Zebu (*Bos indicus*, ♂) from India, presented by Mr. Smith Rylands; two Common Squirrels (*Sciurus vulgaris*), European, presented by Miss E. B. Sparrow; a Martinique Gallinule (*Ionornis martinicus*), captured at sea, presented by Mr. H. A. Pare; a Raven (*Corvus corax*), European, presented Mr. P. Stuart; two Tengmalms Owls (*Nycla tengmalmi*) from Norway, presented by Mr. P. Musters; an Adorned Terrapin (*Chrysemys ornata*) from Central America, presented by Mrs. R. J. Aston; a Common Snake (*Tropidonotus natrix*) from Italy, presented by Mr. T. G. Gunn; a Common Badger (*Meles taxus*) from Siberia, a Common Hamster (*Cricetus frumentarius*, European, a Ring-necked Pheasant (*Phasianus torquatus*) from Mongolia, four Horsfield's Tortoises (*Testudo horsfieldi*) from Central Asia, two Blackish Sternotheres (*Sternothaerus nigricans*) from Madagascar, a Japanese Terrapin (*Clemmys japonica*) from Japan, six Land Lizards (*Lacerta agilis*) from Central Europe, six Crested Anolis (*Anolis cristatellus*) from the West Indies, two Long-snouted Snakes (*Dryophis mycterians*) from India, a Common Snake (*Tropidonotus natrix*), two Common Vipers (*Vipera berus*), British, a Glass Snake (*Ophiosaurus apus*) from Southern Europe, deposited; two Common Wolves (*Canis lupus*, ♂ ♀) from Siberia, two Yellow-tufted Honey-eaters (*Ptilotis auricomis*) from New South Wales, two Nonpareils (*Cyanospiza ciris*, ♂ ♀) from North America, purchased.

## OUR ASTRONOMICAL COLUMN.

Tempel's Comet 1899 *c* (1873 II.).—

*Ephemeris for* 12*h*. *Paris Mean Time.*

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Mars during Opposition 1898–1899.—MM. Flammarion and Antoniadi contribute to *Astr. Nach.* (Bd. 150, No. 3581) the results of their observations of Mars during the last opposition of the planet. The work was done at the Observatory of Juvisy, with an objective by Mailhat of 0·26m. aperture and 3·81m. focal length. The magnifying powers employed were 145, 224, 308, 411, and 607, the best images being obtained with the power of 308. Tables are given showing the progressive diminution in the extent of the polar caps, and of the whitening of the land surface under varying degrees of obliquity of the sun's rays. Two plates accompany the paper, showing the whole of the details observed, and in the description of these several differences are noted in comparison with the data given by Lowell.

As indicating the probable transparency of the Martian atmosphere, mention is made of the visibility of the Mare Tyrrhenum as a black marking quite up to the edge of the disc. The number of canals seen at Juvisy has been thirty-six, the majority of which were large and diffuse. Those easiest seen were Boréosyrtes, Cerberus and Styx. Several observations of gemination were made, which it is thought will throw some light on the cause of the phenomenon.

Photography of Nebulæ and Star Clusters.—At the meeting of May 3 of the Astronomical Society of France, M. L. Rabourdin, in the course of a paper on the history of the subject, showed some remarkably fine photographs of nebulæ and star clusters, and he gives a description of them, and of how they were obtained, in the July number of the Society's *Bulletin* (*Bull. Soc. Ast. Fr.*, July, pp. 289–299). The instrument was the large reflector of the observatory at Meudon, which was kindly placed at M. Rabourdin's disposal by M. Janssen. It has an aperture of one metre and a focal length of three metres, and is thus admirably fitted for the photography of faint objects of extended area. In the same number (pp. 299–304), M. Janssen furnishes some remarks on the above paper, entering fully into the question of astronomical photography, in the course of which he suggests obtaining a photometric scale for the measurement of the brightness of nebulæ by putting standard stars slightly out of focus, thus obtaining small circular discs on the plate instead of points, and then measuring the opacity of these circles.

## EXPERIMENTAL INVESTIGATIONS ON TELEGONY.[1]

### I. *Introductory.*

The belief in telegony, or what used to be known as the "infection of the germ" or "throwing back" to a previous sire, has long prevailed. It may for all we know be as old as the belief in "mental impressions," which has had its adherents since at least the time of the patriarchs. During the eighteenth century the "infection" doctrine was frequently discussed by physiologists, and since Lord Morton, in 1820, addressed a letter to the Royal Society on the subject, believers in "infection" have been increasing all over the world, with the result that one seldom now hears of breeders or fanciers who are not influenced by the doctrine, while physicians and others interested in the problems of heredity either as a rule take telegony for granted or see nothing improbable in the "infection" hypothesis.

It must, however, be admitted that, notwithstanding the criticisms of Weismann and others, very different views are entertained by the believers in telegony, not only as to the cause, but as to the results, of "infection." By some telegony is confounded with simple reversion or atavism, while the better informed generally assume that "infection" invariably results in the subsequent offspring repeating more or less accurately the characters of the first or of a previous sire. In a breeders' journal of some standing there appeared recently under the heading "Colour of Animals" the following sentence:—"Greys show in breeding a great tenacity of assertion. as they are few in comparison to other colours in the Stud Book, but they reappear and no doubt go back to the Arab, and prove telegony to be a fact" (*Live Stock Journal*, May 12, 1899, p. 588). This shows simple reversion is sometimes mistaken for telegony. In support of the view that "infec-

[1] "Experimental Contributions to the Theory of Heredity. A. Telegony." By Prof. J. C. Ewart, F.R.S., University of Edinburgh. (A paper read before the Royal Society, June 1.)

tion" is commonly supposed to lead to "throwing back" to a previous sire many instances could be given, but the following from an article on telegony by De Varigny will suffice. De Varigny states that an ordinary cat which had kittens to a tailless Manx cat subsequently produced several tailless kittens to a normal cat of her own breed (*Journal des Débats*, September 9, 1897).

An extended series of experiments with various kinds of animals has led me to the conclusion that if there is such a thing as telegony it is more likely to result in the subsequent offspring "throwing back" to an ancestor of the "infected" dam than to a previous mate. This view of telegony (which has not been insisted on hitherto) will be made at once evident by an example. A sable collie crossed with a Dalmatian produced three pups which in their coloration are extremely like young foxhounds; instead of numerous small spots each has a few large blotches. According to the common view of telegony this collie, if infected, should next produce with a dog of her own breed one or more Dalmatian-like pups. If, however, the offspring of a collie and a Dalmatian are like foxhounds the subsequent offspring to a collie of the same colour and strain could hardly be expected to present Dalmatian characters, *i.e.* show numerous small spots. But if "infection" as a rule results in the subsequent offspring "throwing back" either to the ancestors of the sire or the dam, it will be extremely difficult, if not in many cases impossible, to distinguish telegony from simple reversion.[1]

But though "infection," if it does take place, is likely, as a rule, to lead the subsequent offspring to resemble the ancestors of the dam, it may in certain cases possibly lead to their "throwing back" to a previous sire. This result might follow if the previous sire happened to be highly prepotent. For example, Highland heifers often produce to a Galloway bull hornless black offspring indistinguishable from pure Galloways. If infected by the Galloway bull, these heifers might afterwards produce Galloway-like calves when mated with long-horned bright coloured bulls of their own breed.

It is now commonly believed that if there is such a thing as telegony it results from the unused germ cells of the first (or previous) sire infecting—blending with—the unripe germ cells in the ovaries of the dam. Were this possible, the subsequent progeny would in all probability in a mild way resemble the previous sire, but if this is impossible then infection—due perhaps to some obscure change in the constitution or reproductive system of the dam—is more likely to lead to more or less marked reversion to the ancestors of the dam. All my observations point to its being impossible in the Equidæ for the unused male germ cells of the first sire to infect the unripe ova. The spermatozoa lodged in the upper dilated part of the oviduct of the mare are dead, and in process of disintegrating, eight days after insemination; they probably lose their fertilising power in four or five days. There is no reason for supposing that in the Equidæ they survive longer in or around the ovary. Further, though at the time of fertilisation there may be several large Graafian follicles in each ovary containing maturing ova, all these follicles disappear long before the period of gestation is completed. The subsequent foals are developed from successive new crops of ova into the composition of which it is inconceivable any of the spermatozoa of the first sire could by any chance enter. A study of the ovaries hence tends to confirm the view that "infection" (if there is such a thing) is as likely to cause reversion to a former ancestor of the dam as a "throwing back" to a previous sire.

Having made these general observations, it will be well next to consider critically the case of "infection" communicated in the letter to the President of the Royal Society in 1820[2] by the Earl of Morton. Though many other instances of supposed "infection" have been recorded, Lord Morton's mare may be said to still hold the field—the theory of telegony still mainly rests on the assumption that this historic mare was "infected" by a quagga some years before she passed into the hands of Sir Gore Ouseley and produced three "colts" to a black Arabian horse. One might even go further and without much exaggeration assert that the telegony hypothesis at the present moment mainly rests on an allegation by Sir Gore Ouseley's stud groom.

It has been generally assumed that Lord Morton's mare (a nearly purely bred chestnut Arab) was "infected" for two reasons (1) because the subsequent offspring were of a yellowish-brown colour and more or less striped, and (2) because, according to Sir Gore Ouseley's stud groom, the mane of one of the striped foals had always been upright, while in another it arched to one side clear of the neck. The presence of stripes in the subsequent offspring has never been questioned, nor yet is there any doubt that when Lord Morton in 1820 inspected the "colts" the mane in the filly was upright as in the quagga, while that of the colt resembled the mane of Lord Morton's quagga hybrid. There is, however, an absence of trustworthy evidence that the filly's mane had *always* been upright as alleged to Lord Morton by Sir Gore Ouseley's stud groom.

Were the evidence in support of this allegation satisfactory, there would I think be no escape from the conclusion that Lord Morton's mare was "infected" by the quagga. Hitherto the presence of stripes on the "colts" has generally been looked upon as affording strong evidence of "infection." Believers in telegony admit that stripes are not uncommon in Norwegian and certain other breeds of horses, but, with Mr. Darwin, they have taken for granted that they never or very rarely occur in Arabs.

I find, however, that though in Arabia dun-coloured horses are disliked and never used for breeding, stripes even in the most renowned strains are not so uncommon as is generally supposed. I have now a purely bred Arab filly of about the same colour as Lord Morton's filly, but, unlike the filly we have heard so much of, both the fore and hind legs are marked with distinct dark bars, and there are faint indications of stripes across the withers and a distinct dorsal band. The history of this filly (bred by Mr. Wilfred Scawen Blunt at Crabbet Park, Sussex, and very kindly presented to me) is well known for many generations; none of her ancestors could possibly have been "infected" by a zebra. The dun colour and stripes are doubtless the result of simple spontaneous reversion, for, unlike Lord Morton's mare, there is no history of a cross in her pedigree. This filly proves that even in high-caste Arabs of the best desert blood a dun colour and stripes may unexpectedly appear.

As to the occurrence of stripes in other breeds I could give, were it necessary, many instances. A year ago I had in my possession a light bay (or yellow dun) pony, which showed nearly as many stripes on the trunk as the Gore-Ouseley filly, and in addition had several interrupted narrow stripes on the forehead.[1] Moreover, the stripes on the Gore-Ouseley "colts," while agreeing with stripes occasionally seen in horses, differ in their arrangement from the stripes in the quagga. The stripes themselves are evidence of reversion, but nothing more; and seeing that pure bred horses sometimes show quite as many stripes, we are not justified in assuming that but for the dam of the "colts" having been first mated with a quagga the stripes would not have appeared.

Hence unless it is proved that the mane in the filly and colt were naturally erect, or nearly erect, the case for the "infection" of Lord Morton's mare will be lost. It may be well to quote the passage from Lord Morton's letter referring to the mane. It is as follows:—"That of the filly is short, stiff, and upright, and Sir Gore Ouseley's stud groom alleged it never was otherwise. That of the colt is long, but so stiff as to arch upwards and to hang clear of the neck, in which circumstance it resembles that of the hybrid. This is the more remarkable as the manes of the Arabian breed hang lank and closer to the neck than that of most others" (*Phil. Trans.* 1821).

I am not prepared to accept the allegation as to the manes for the following reasons:—

(1) I have had twelve zebra hybrids under observation, and in each case the mane, though erect to start with, always after a time arched over to one or both sides. The stud groom's statement, it seems to me, proves too much. If in the quagga hybrid and in all my horse hybrids the mane, sooner or later, falls to one side it is a little remarkable that in the pure bred two-year-old filly it had been always upright.

I may here mention that the hair of the mane of zebra hybrids is shed annually; it is for this reason that the mane in hybrids is never long enough to hang close to the neck.

(2) The mane in the drawing of the filly by Agassé is no

[1] That reversion ever occurs has been questioned by Bateson ("Materials for the Study of Variation") and others, but I have already (NATURE, February 9, 1899) proved beyond doubt that reversion can be easily induced by intercrossing distinct types, and I have recently heard of several instances of spontaneous reversion—reversion not induced by intercrossing.

[2] *Phil. Trans.*, 1821.

[1] See Fig. 36, "The Penycuik Experiments," A. and C. Black, 1899.

represented as upright, but as lying to one side. If the mane had remained erect during the first two years, by virtue of shedding its hairs, it could not very well have lost this habit and fallen completely over to one side subsequently, say, during the fourth year. From the mane being erect in 1820, and hanging to one side in 1821 or 1822, when Agassé's drawing was made, the presumption is that the mane of the "colts" had been cut some time before they were examined by Lord Morton.

Two years ago I had a bay Arab with a mane which was to start with short, stiff and upright; some months later it arched freely to one side, as in my zebra hybrids, and later still it hung lank and close to the neck.

(3) There is always an intimate relation in the Equidæ between the mane and the tail; when the mane is short and erect the upper third or so of the tail is only covered with short hairs, which, like the hairs of the mane, are annually shed. Lord Morton noticed nothing peculiar about the tail of the "colts," and the tail of both the colt and filly in Agassé's drawings is the tail of a high-caste Arab. This seems to me to warrant the conclusion that the filly's mane had been hogged some time before Lord Morton's visit.

It thus appears that the evidence in support of the belief that Lord Morton's mare was "infected" by the quagga is at the best far from satisfactory. The same may be said of the evidence in support of all the other supposed cases of telegony in the Equidæ—of, amongst others, Lord Mostyn's mare, referred to by Darwin ("Animals and Plants," vol. i. p. 435, 1875); of the mule-like mare in the Paris Gardens, referred to by Tegetmeier and Sutherland ("Horses, Asses and Zebras," p. 81); and of the African ass (*Equus asinus*), still in the Zoological Gardens (London), which now and then has a reddish-coloured foal, like the cross-bred foal she produced in 1883 to an Asiatic ass (*E. hemionus*).

Although I am now satisfied that Lord Morton's case throws little light on the telegony hypothesis, like many others I had no very decided views on the subject some years ago, and hence when arranging in 1894 to make a collection of horse embryos, I decided to repeat, as far as circumstances permitted, what is commonly called Lord Morton's experiment. For this purpose I procured early in 1895 three zebras and a number of mares. Two of the zebras died during the winter of 1895, but the third—a handsome stallion of the Chapman variety (*E. burchelli* v. *chapmani*)—still survives and is now thoroughly acclimatised.

During 1895 I only succeeded in mating the zebra with one mare, and hence there was only one hybrid born in 1896. During the last two years, however, quite a number of hybrids have made their appearance, and the dams of several of the hybrids have subsequently produced pure-bred foals. The time has hence come when some of the results of the experiments may with propriety be communicated to the Royal Society.

"II. *Experiments with West Highland Ponies.*" *By Lord Arthur Cecil, Orchardmains, Kent, and J. C. Ewart.*

The first mare mated with the zebra was a black West Highland pony (Mulatto), set apart for the telegony experiments by Lord Arthur Cecil. The better bred West Highland ponies are supposed to have descended from "Armada" horses, and are hence perhaps related to Mexican and Argentine horses, so often dun-coloured and partially striped. Mulatto's hybrid (Romulus, born August 12, 1896) is, on the whole, more a zebra than a pony both mentally and physically. He is especially remarkable in being more profusely striped than his sire (the zebra Matopo) in having a heavy semi-erect mane, which is shed annually, and in having a mule-like tail from the upper third of which the longer hairs are periodically shed. The body colour of the hybrid varies from a dark orange colour to a mouse-dun; the stripes, of a reddish-brown colour, on the head are dark brown or nearly black on the trunk and limbs.

In the number and plan of the stripes, the hybrid agrees more closely with the Somali zebra than with any of the Burchell zebras. Over the brow, *e.g.* there are narrow rounded arches instead of somewhat broad pointed arches as in his sire, the neck and trunk have quite double the number of stripes found in the sire, while over the croup in the position of the "gridiron" of the mountain zebra there were at birth irregular rows of spots, which in course of time blended to form somewhat zig-zag, narrow, transverse bands. The ears are nearly as large as in the sire, while the eyelashes are longer and distinctly curved. In his movements the hybrid resembles his sire, and like his sire he is always on the alert, very active and suspicious of unfamiliar objects. Further, in his call he agrees far more with his sire than his dam. In being profusely striped, Romulus differs greatly from the quagga hybrid bred by Lord Morton, in which the stripes were fewer in number than in many dun-coloured horses.

Mulatto's second foal arrived in July 1897, the sire, Benazrek, being a high-caste grey Arab horse. Like Lord Morton's colts, Mulatto's foal by the Arab horse, in make, action and temperament, agreed with ordinary foals, but it differed from the majority of foals in presenting quite a number of *indistinct* stripes—subtle markings only visible in certain lights. These stripes differed but little from the body colour, which varied from dark bay to brown. Though few references have been made to the occurrence of stripes in foals, they are, we find, far from uncommon. As is well known, Mr. Darwin once bred a striped foal by putting a cross-bred bay mare to a thoroughbred horse. This foal was for a time marked nearly all over with obscure dark narrow stripes, plainest on the forehead, but also distinct over the croup ("Animals and Plants," vol. i. p. 60).

There is no figure of Mr. Darwin's striped foal, but from the description given there can be little doubt that the markings were more abundant than in Mulatto's second foal. In this foal (as in Mr. Darwin's) the stripes became more and more indistinct, and by November they had almost vanished. Unfortunately the foal died when about five months old, and hence it is impossible to say whether any of the stripes would have persisted. It will be evident that Mulatto's second foal helped but little to clear up the vexed "infection" problem. Mulatto missed having a foal in 1898, but she recently produced at Knole, Kent, her third foal. The sire (Loch Corrie) of this foal belongs to the Island of Rum section of the West Highland ponies, and closely resembles Mulatto. The third foal has about as many stripes as the second. As in the second, they are most distinct over the croup and hind-quarters; and as in the second, they differ both from the markings in the previous sire, the zebra, and from the markings on the hybrid Romulus.

This third foal, which was born on May 6, 1899, seemed, like the second, to lend some support to the "infection" hypothesis. Fortunately, since it made its appearance, two other West Highland mares have had foals to Loch Corrie. These foals put all doubt as to the nature and significance of the stripes on Mulatto's second and third foals at an end.

One of the dams is of a brown colour, the other is nearly black. Though neither the brown dam nor the black has ever seen a zebra, both foals are marked in very much the same way as Mulatto's, and some of the stripes in one of the new foals look more like persisting than the stripes on Mulatto's third foal. Hence, in order to account for the markings on Mulatto's foal to the grey Arab, and on her foal to the black West Highland pony, it is unnecessary to fall back on the "infection" hypothesis.

"III. *Experiments with Shetland, Iceland, Irish, Thoroughbred and other Ponies.*" *By J. C. Ewart.*

An effort was made to cross four Shetland ponies with the zebra stallion, but I only succeeded in obtaining one hybrid. The dam (Nora) of this hybrid closely resembles, except in size, the Island of Rum ponies—she is a small edition of Mulatto. Her first foal, by a black Shetland pony, was of a dun colour, and nearly as striped as Sir Gore Ouseley's filly; her second is the most zebra-like of all my hybrids; her third closely resembles her sire, a bay Welsh pony. For some time after birth there were faint indications of stripes over the hind-quarters of this foal, but now it is a year old there are no markings or any other suggestions of a zebra. It is not a little suggestive that the foal bred from this pony before she was mated with the zebra was distinctly striped, while the subsequent pure bred foal has no stripes.

Of five Iceland ponies put to the zebra only one produced a hybrid. This hybrid was faintly striped, and showed less of the zebra than any of the others. The dam, a prepotent yellow and white (skewbald) pony, had first of all a light bay foal to an Iceland pony. Her third foal, by a bay Shetland stallion, is a skewbald, and in the size and arrangement of the brown patches closely resembles the dam. There is no hint whatever that the Iceland pony has been "infected" by the zebra.

Several Irish mares were put to the zebra, and two of them (bays) have first produced hybrids and subsequently pure bred foals. A cream-coloured Irish-Canadian mare unfortunately died before her hybrid foal was born. One of the bay mares

had a bay hybrid richly striped; the other a hybrid with but indistinct stripes. The subsequent foals—one by a chestnut thoroughbred horse (Tupgill), the other by a hackney pony (Mars Royal)—are bays, not only devoid of stripes, but affording no indication whatever that their dams had been previously mated with a zebra.

Although I experimented with seven English thoroughbred mares and an Arab mare, I only succeeded with one—a small chestnut. This mare produced twin hybrids last summer; she has this summer a foal to a thoroughbred chestnut horse (Lockstitch). One of the twins died soon after birth, the other, richly but unobtrusively striped, in its colour and make strongly suggests his dam. The chestnut mare's new foal neither in make, colour nor action in any way resembles a young zebra nor a zebra hybrid. In 1897 a bay mare by a bay Arab horse (Hadeed) was for some months in foal to the zebra. Since she miscarried in 1896 she has had two foals to a thoroughbred horse (Lockstitch). Neither of these foals in any way suggests a zebra. In this case the unused germ cells of the zebra had presumably a better chance of reaching the ovum from which the first of the two pure-bred foals was developed than is usually the case.

Attempts were made to cross Welsh, Exmoor, New Forest, Norwegian and Highland ponies with the zebra without success, and though a cross-bred Clydesdale has twice had a hybrid, she has not yet produced a pure-bred foal. The experiments, as far as they have gone, afford no evidence in support of the telegony hypothesis.

## *INVESTIGATIONS ON MOSQUITOES AND MALARIA.*[1]

I HAVE the honour to report the results of my observations since my arrival here on December 21, 1898.

Major Ross, I.M.S., first demonstrated and explained to me his method of dissection of the mosquito and the structures normally met with. From prepared specimens he then showed me the bodies met with after feeding these mosquitoes on birds infected with the proteosoma and the change day by day which they showed, ending with a demonstration of the germinal threads in cysts in the stomach wall, as seen in the fluids of the body and in cells in the salivary gland.

On my arrival there were in the laboratory, in test-tubes, series of mosquitoes fed on birds infected with proteosoma on the night of November 30, December 10, December 12, December 15, and December 20.

Of each of these series Major Ross dissected specimens for me after killing the mosquitoes with chloroform, and again demonstrated in these the same bodies that he had already shown me in prepared specimens; pointing out and demonstrating as he went on that in the older mosquitoes it was possible on cutting the thorax to observe the nature of the contents both of the coccidia in the stomach and of those of the cells of the salivary glands.

The points showed to me I readily observed.

From series of mosquitoes before mentioned I day by day examined both those which died and others I killed, and was as readily able myself to repeat the observations and in the earlier series to trace the changes in the size and nature of contents of the coccidia.

I also examined a large number of mosquitoes caught about the laboratory, and others which had been raised from larvæ. In no case did I find either coccidia in the stomach wall, germinal threads in the body fluids, or in the cells in the salivary gland; nor did I find "black spores" in them.

Major Ross informed me that his published results were based on observations made in the hot season when the temperature was 80° F., or more; and that now I should find the changes considerably slower, as it was the cool season, but that the sequence of events was the same.

My observations on the mosquitoes fed on December 20 and December 15 showed that this was the case, and that the coccidia advanced more slowly than the published results indicated. He also informed me that mosquitoes fed less readily and more difficulty was met with in rearing them to a spore-bearing age.

[1] Dr. Daniels's Report to the Secretary of the Malaria Investigation Committee of the Royal Society, London, on the results of observations made by him in Calcutta in conjunction with Major Ross, I.M.S. Dated Calcutta, January 23.

These difficulties the use of the incubator was only partially successful in obviating.

On the evening of January 1, following exactly in Major Ross's lines, I commenced a repetition of his main experiment. Two mosquito nets, free from rents, were taken, and in them were released a large number of grey mosquitoes reared from larvæ.

In the one, four birds were placed; in three of them on December 31 I had found proteosoma in large numbers, and in the fourth a moderate number.

In the other net two birds, in whose blood no proteosoma had been found, were placed; these two died two and three weeks later, and no pigment was found in their organs, and repeated examinations of their blood had failed to show proteosoma.

On January 2 none of the mosquitoes had fed, and on January 3 only two in the first net and eight in the second. On January 4, a warm night with a minimum temperature of 59·2° F., sixty-three mosquitoes were found gorged with blood in the morning, and were caught in separate test-tubes plugged with wool and placed in the incubator. Eighteen in the other net, where the non-infected birds were placed, the control series, were similarly collected; these were caught in the same manner and treated in the same way.

On the following two evenings, with minimum temperatures of 60·7° and 63·2°, sixty-eight and forty-six mosquitoes were fed on the infected birds and were kept for the preparation of specimens. Twelve mosquitoes were fed on the non-infected birds, and were used as additional controls so as to bring the number of the control on Blue Jay with numerous Halteridia.

On the third day the sixty-three, with the exception of those killed for examination or dead, were released inside a clean net free from mosquitoes, and birds free from proteosoma were also placed in it.

In the morning all mosquitoes found inside were collected, and most of them had fed well; the minimum temperature was 63·2° F.

This is the method Ross employs to re-feed the mosquitoes. If infected birds are used, you get a younger generation of coccidia; so I used sterile birds. The method works fairly well in warm weather; but there is always some loss, as the full number are not collected again in the morning. As the process is repeated over and over again, this loss becomes serious, the more so the longer the period required for maturation. In a frequently repeated process of this kind there is always the possibility of an outside mosquito getting in.

The mosquitoes were not fed on the following night, as they were full of blood; but most of them voided it during the night, and many died next day.

The remainder were given the opportunity of re-feeding every night after this; but a spell of cold weather ensued with minimum temperatures of 44° F.–49° F.; only on one night did it exceed 50° F., and on these nights few fed well or at all, and there was a consequent continued heavy mortality, only one being alive on the tenth day, and that subsequently escaped in the night.

This method of feeding is very unsatisfactory in exceptional weather of this kind; the mosquitoes in the day are kept warm in the incubator, and rapidly digest their food, whilst at night the cold renders them torpid and they do not feed.

The control mosquitoes were treated in exactly the same manner and fed on birds free from proteosoma. The last died on the thirteenth day.

The results of the two series are as follows:—

> Sixty-three fed on proteosomal birds.
> Forty-nine examined, three reserved for sections, one too much decomposed for satisfactory examination.
> Ten not accounted for, lost in the nets.

Of the forty-nine examined, two were killed on the first day—that is, under twenty four hours, and possibly under twelve hours, after they had fed. No coccidia were found in these. Two more were examined the following morning, under thirty-six and possibly under twenty-four hours after they had fed; no coccidia were found in these.

In two examined about 4 p.m., the minute pigmented coccidia were found; that is, under forty-six and possibly not more than thirty-four hours after they had fed on the infected birds.

The remainder were examined on the following days, the largest numbers, eighteen, on the fourth day and twelve on the seventh day, as on these two days those numbers died.

In every mosquito examined, with one exception, the coccidia were found usually in numbers, but in one there was only one coccidia.

The exception occurred on the ninth day; as by then they had been re-fed several times, it may have been an outside one which had effected an entrance.

So that out of forty-five mosquitoes fed on the infected birds and examined more than thirty-four hours after, forty-four contained coccidia.

This I may say is a more successful result than in the other series I have seen.

The other two sets of mosquitoes were used by all of us for preparation of specimens, and no record was kept of the number of failures. From my own examination only about three-fourths of them developed coccidia.

The treatment was a little different, and half of them were not incubated for several days.

Of the controls fed on birds free from proteosoma, thirty-eight in number and treated in the same manner, twenty-nine were examined and nine are unaccounted for—"lost in the nets." None of the twenty-nine were examined on the first day, but one was in the afternoon of the second day. The largest number examined were on what would correspond to the fourth and seventh days, *i.e.* seven and five; but there were four each on the fifth and sixth days.

It will be observed that these control mosquitoes were not, as the other series, collected on one, but on three nights. A very slight difference in breeze and light seems to affect the number who bite; or any extra restlessness on the part of the birds would have the same result.

In none of these twenty-nine were coccidia found. Of the eighteen fed on the Blue Jay with Halteridia, twelve were examined from two to six days after feeding and none contained coccidia.

The forms found on the second day measured 6–7 $\mu$, some of them a little more. They were oval bodies containing scattered granules of black pigment, and had a sharp, clear outline.

I incised the stomach, and by repeated washing and compression with a cover-glass was able, not only to wash out the contents of the stomach, but even to express the loosely attached epithelium, so as to leave the stomach as a transparent clear bag. To this outer wall the majority of coccidia remained fixed, though in one of the mosquitoes I observed some to escape with the epithelium. At no subsequent date could I ever detach any by this process, though some coccidia would be ruptured.

The next morning the smallest measured 10 $\mu$; some were 12 $\mu$. On the sixth day they were met with up to 30 $\mu$; by this time the pigment had absolutely as well as relatively diminished.

In another three days some of them reached 60 $\mu$; and in the last of the series examined (tenth day) there were coccidia measuring 70 $\mu$.

The coccidia could now be seen to project from the outer wall of the stomach; very few contained pigment, and that in small amount.

Some of the coccidia were clear and others had a granular appearance, but in none were there either black spores or germinal threads to be seen.

For the further development the early deaths of the mosquitoes from the inclemency of the weather rendered this series useless.

One of those which were infected on the night of January 5, and another infected on January 7, did reach this stage; and in the last of those first fed on January 5, which died on January 22, ruptured cysts were found by me in the stomach wall, as well as numerous cysts containing mature germinal threads, and these threads were also found in the body fluids and in cells in the salivary glands.

My observations are, therefore, mainly based on those infected November 30 and subsequent dates before my arrival, and on some infected December 22. The one infected on January 5 died on January 19, and the coccidia in it had an appearance of striation.

On adding salt solution (gr. xv. to the ounce) and pressing on the cover-glass, a projecting coccidium was ruptured; and the contents poured into the fluid, leaving the cyst wall still attached to the stomach.

The contents were seen to consist of a mass of shrivelled threads. This appearance in the other series mentioned I have frequently seen.

These threads, Ross's germinal threads, are sickle-shaped bodies about 14·15 $\mu$ in length, they stain with logwood or methyl blue, but not strongly; on adding water or Farrant's solution they lose their shrivelled appearance and become more rounded. Nearer one end than the other is an unstained portion (? nucleus).

They show no signs of movement; but as they are invisible in water and only become visible when shrivelled by the salt or stained, it may be doubted if they have been seen alive.

If a mosquito has its thorax incised when rather older than this, similar threads are found in the fluid exuded if salt solution is added to it.

In such a case ruptured cysts are found in the stomach wall.

The position as regards the salivary gland involves a difficulty which is not met with in any other part of the examination.

The dissection of the stomach is easy; that of the salivary gland in its entirety is not, and for some reason appears to be more difficult in the old infected mosquitoes. Any rough manipulation results in the detachment of the cells, and little more than the duct is left. In most cases, however, one entire gland, or portions of both, can be exposed in fair condition even in old infected mosquitoes.

In every case where this was done and germinal threads were found in the body-fluids, the germinal threads were also found in some of the cells in the salivary gland, and no similar threads have I found in a large number of salivary glands examined by me in mosquitoes bred from larvæ, free about the laboratory, or in the earlier stages of coccidial infection.

The affected cells can be distinguished with a low power, as they have a granular appearance, whilst the unaffected cells are quite clear.

With a high power, if not very numerous, the isolated germinal threads can be clearly distinguished and recognised by their peculiar shape and shrivelled appearance (the examination must be made in salt solution). If numerous, the individual threads can be no more distinguished than in the coccidia, but, as in those, pressure on the cover-glass will rupture the cell, and the germinal threads are then poured out.

The threads do not fill the cell. There is a faintly granular crescentic portion on the side most remote from the duct, which in many cases at least is free. The part of the cell in which the threads lie must be nearly fluid, as it permits oscillations ot the threads to take place.

On these points I have satisfied myself by repeated examinations, though the appearances are by no means difficult to make out; and have gone at some length into the question, as so far we have found no satisfactory method of making permanent preparation. All the preservatives at our disposal wrinkle up the delicate cells, with the exception to some extent of weak formation solution; and I have no confidence in that as a means of making permanent specimens.

The whole gland is never involved. In one dissection made by Ross the cells in both middle lobes and in no other part of the gland contained the threads. In several cases where one gland has been exposed entire, the middle lobe alone has been involved; but in the majority all that can be stated with certainty is that the cells in one portion of the gland contain threads, and in other portions they do not.

The following specific observations made by myself on mosquitoes dissected by Major Ross, Dr. Rivenberg of the American Mission, who is working with Dr. Ross, and myself may be of interest.

(*a*) Coccidial cysts full of apparently mature germinal threads, no ruptured cysts, no germinal threads in the body fluids or salivary glands. Two observations.

(*b*) Cysts full of germinal threads, other ruptured empty cysts, germinal threads in body fluids, germinal threads in salivary glands. Over twenty observations.

(*c*) Empty cysts in stomach wall, germinal threads in body fluids of thorax. Germinal threads in salivary glands. No cysts still containing germinal threads. Two observations.

(*d*) Empty cysts only in stomach wall, no germinal threads in body cavity, no germinal threads in well-exposed salivary glands. One observation, the mosquito had been infected four weeks before death.

These observations fully confirm Ross's statements in every point. They indicate that the threads are formed in the coccidia, that they escape on the rupture of these into the body-cavity and

are again collected in the salivary glands. I should have liked to extend the series, but the continued cold weather renders it improbable that I shall be able to do so before I leave.

With your permission I should like to publish an abstract of this, confirming Ross's work; and to this Major Ross consents.

In case you should consider this advisable, I am, to avoid delay, forwarding an abstract to Dr. Manson, with a request to him to forward it to the *British Medical Journal*, if your consent is granted.

The infection of birds free from proteosoma by the bites of mosquitoes.

On December 20, the day before my arrival, twenty-two birds were examined and found free from proteosoma. On that night some of these were used for feeding the mosquitoes which had been infected on November 30 and on the 24th and subsequent days; the remainder of the birds were used for feeding the mosquitoes first infected on November 30 and December 10, 12 and 15. In other mosquitoes of this series germinal threads were found in the salivary glands; and the ones which fed, when examined later, gave the results indicated in paragraph 9.

On December 30 Dr. Rivenberg and myself examined these birds; three of them had proteosoma, two in large numbers.

On January 4 I examined them all except one, which died on January 2; in that the heart's blood contained no proteosoma, and the organs were free from pigment.

Five more of these had now proteosoma, all very numerous. On January 6 and 7 I again examined them; three more had proteosoma, all very numerous.

On January 9 no more cases had developed; but on January 18 one of them had numerous proteosoma, whilst many of the ones which had been infected had recovered, and the others now showed few proteosoma.

Thus twelve out of twenty-two birds became infected, or 54 per cent. This compares unfavourably with Ross's earlier results, as in his published series twenty-two out of twenty-eight were infected, or 79 per cent. But it is to be remembered that at the time he was working the germinal threads were found in a week; whilst in December the development was much slower, and now takes at least twice the time. It is much easier to keep the mosquitoes alive for one week than longer, while in the hot weather mosquitoes bite more readily.

These results are less unfavourable if compared with the normal proportion of birds infected with proteosoma at this season. Thus Ross out of 111 wild birds found proteosoma in 15, or 13·5 per cent.; whilst I find at this season only one with proteosoma out of 30, or 3·3 per cent.

It is possible that in the cold season the birds have a greater power of resistance; and this is rendered more probable by the short duration of the proteosomal attack in my infected birds. Of these twelve, five died within the first week. In three, in which also the proteosoma had been very numerous, none could be found ten days after the invasion; in one, in which they were never numerous, none could be found on the fifth day.

In the other three, very few are now found, though at first they were numerous.

The recovery of these birds and the death of the mosquitoes fed on them diminishes the chances of much future work on this line in the time remaining to me here.

Mention has been made of the differentiation of the contents of the coccidia previous to the formation of the germinal threads into clear and granular; the second of these can be traced day by day into those forming the germinal threads. This differentiation was clearly visible in my series. Instead of germinal threads in a minority of the coccidia, in most mosquitoes, when the germinal threads are mature, black tubular bodies are found in cysts with otherwise clear contents.

These were met with frequently in the series of mosquitoes infected in November and December. Most of these contained some coccidia with black spores; though in few all the cysts contained germinal threads. In some cysts these black spores are numerous and occupy the entire cyst; in other cysts there are only a few. In most cases germinal threads are not found in the same cyst; but there have been a few cysts in which it has been doubtful whether there are germinal threads also in the cyst, or whether there are overlying escaped threads from a neighbouring capsule.

These black spores are very resistent; I have seen some kept in water for months by Ross with no visible change, and they will withstand irrigation with liquor potassæ.

When the cysts are ruptured the spores are found all over the body, but not in cells; nor do they seen to accumulate in any one part of the body.

The most plausible view of the nature of these black spores seems to be that held by Major Ross, viz. that they are "resting spores," and that through them by another cyst the proteosoma can be propagated in conditions unfavourable for direct propagation by injection into a warm-blooded animal.

In that case three courses suggest themselves:

*a*. From them arise bodies capable of non-parasitic life and possibly of reproduction, but capable at certain stages of their existence of introduction into a warm-blooded host by inhalation through drinking water, or even by injection by a mosquito or other blood-sucker transferring them from the medium in which they live directly.

*b*. That they may be ingested by mosquito larvæ, and in them undergo such development as will result in the formation of germinal threads in the adult, which in turn might be injected into the bird.

*c*. That they may, when swallowed or inhaled by a warm-blooded host, so develop as to reach the circulation and pass into the sporulating phase.

Such experiments as have been made are inconclusive; and it is obvious that till the nature of these "black spores" is determined we cannot exclude, even for the proteosoma of sparrows, the possibility of some one of the many alternative possible channels of infection, some of which would only require the occasional intervention of an intermediate host.

Still less are we justified in concluding that malaria in man can only be acquired from the mosquito, or devoting our exclusive attention to that channel.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

Dr. E. H. Starling, F.R.S., has been elected to the Jodrell professorship of physiology in University College, London, in succession to Prof. E. A. Schäfer.

Dr. Sutherland, assistant professor of pathology, Glasgow, has been appointed professor of pathology in St. Andrews University, in succession to Prof. Muir, recently appointed to Glasgow.

For some time past the School Management Committee of the London School Board have been considering communications sent to them with reference to the metric system. It has now been resolved to send a memorandum to the Education Department containing proposals for amplifying the teaching of the system by a definite curriculum for each standard.

The Board of Education Bill was read a third time in the House of Commons on Tuesday. An animated discussion took place upon the various clauses of the Bill, and several amendments were proposed, but no changes of any importance were made. One of the amendments moved had for its object the omission of the words which empower the Board of Education to employ for the purpose of school inspection "other organisations" besides the Universities. These words were struck out in the House of Lords, and re-inserted in Grand Committee in the Commons. The proposal to again delete the "other organisations" was negatived.

At a meeting of the council of the City and Guilds of London Institute held on Monday it was resolved to confer the Fellowship of the Institute upon Mr. William J. Pope for the valuable and original chemical research work which he has done since he gained his diploma of associate of the institute in 1890; and upon Mr. Arthur E. Childs for the services he has rendered in developing several new branches of engineering industry since he gained his diploma in 1891. The Fellowship is conferred by the council upon those who, having obtained the associateship of the institute and spent at least five years in actual practice, produce evidence of having done some original and valuable research work, or of having otherwise contributed to the advancement of the industry in which they are engaged.

The Agricultural and Technical Education (Ireland) Bill was read a second time in the House of Lords on Monday. Lord Ashbourne, in moving the second reading of the Bill, said its object is to promote and foster agriculture and all the kindred interests, and also to promote technical education. The Bill in its mechanical part proposes the creation of a department com-

posed of the Chief Secretary, a vice-president, and officials, for whose appointment powers are given. To them will be transferred various powers now scattered over other boards. As to the financial resources to be placed at the disposal of the new department, it is calculated that the total income from all sources will amount to from 160,000*l.* to 170,000*l.* a year; and this money will be applied to aiding and encouraging agriculture and other industries and technical instruction. The board to be formed under the Bill will be aided and advised by three bodies to be called into existence—a council of agriculture, a board of technical instruction, and an agricultural board—which will have very wide and important duties to perform. Speaking broadly and generally, the income of the board is to be devoted as follows: 55,000*l.* to technical instruction; 10,000*l.* to the improvement and development of the sea fisheries; and the remainder to agriculture and rural industries.

## *SOCIETIES AND ACADEMIES.*

### PARIS.

**Academy of Sciences**, July 24.—M. van Tieghem in the chair.—Presence of iodine in notable proportions in all plants containing chlorophyll of the Algæ class, by M. Armand Gautier. As a result of numerous estimations of iodine in Algæ containing chlorophyll it was found that iodine is a constant element of the protoplasm of these plants, both in sea water and fresh water, the latter, however, containing much smaller quantities of iodine. Thus, where 100 grams of dried marine Algæ give 60 mgr. of iodine, the same weight of fresh water Algæ gave only 0·25 to 2·4 mgr.—On the theory of partial differential equations, by M. N. Saltykow. The author's previous work on this subject was restricted to equations resolved with respect to partial differentials. Since, however, the solutions of the equations may offer considerable difficulties from the point of view of practical applications, the theory of any equations whatever in involution is here given.—On indeterminate equations of the form $x^\lambda + y^\lambda = cz^\lambda$, by M. Edmond Maillet.—On a correspondence between two ruled spaces, by M. A. Demoulin.—On the magnetic field inside a hollow cylinder traversed by a current, by M. W. de Nickolaieve.—On the dielectric cohesion of rarefied gases, by M. E. Bouty. In a preceding note it has been shown that when a tube containing a rarefied gas is placed in an electrostatic field, there is a critical intensity of field, $f$, below which the gas acts as a perfect dielectric and above which the gas allows the passage of a discharge. In the present paper the relation between the critical intensity, $f$, and the pressure of the gas, $p$, is quantitatively examined, and the result expressed in the form

$$f = A\left(1 + Bp + \frac{C}{p}\right),$$

where A, B, C, are constants, B, and perhaps C, being independent of the nature of the gas, and A increasing with the molecular weight of the gas.—The instantaneous disappearance of the Kerr phenomenon, by MM. H. Abraham and J. Lemoine. By the use of a rotating mirror M. Blondlot has shown that the time that elapses between the suppression of the electric field and the disappearance of the Kerr effect is less than 1/40,000 of a second. In the present paper it is shown by a different method that the time cannot exceed 1/10,000 of this, namely 1/400,000,000th of a second.—On the isomeric states of chromic acetate, by M. A. Recoura. A detailed description of the normal acetate, possessing the properties of an ordinary metallic salt, and the violet acetate, in cold solutions of which alkalis give no precipitate.—Mixed copper-silver salts, by M. Paul Sabatier. The salts described are the basic nitrates, $3Cu(OH)_2.2AgNO_3$, and $2Cu(OH)_2.2AgNO_3$, two similar chlorates, the sulphate, $3Cu(OH)_2.Ag_2SO_4$, and the thiosulphate $2Cu(OH)_2.Ag_2S_2O_3$.—On the purification of iridium, by M. E. Leidié. The method suggested is based upon the conversion of the metal into chlorides, and subsequent use of sodium nitrite. The iron and lead are first precipitated as oxides, and gold as the metal, the solution then containing double nitrites of ruthenium, rhodium, and iridium, and sodium osmiate. The ruthenium and osmium are eliminated as volatile peroxides, and the rhodium and iridium converted into the double chlorides with sodium chloride, these being readily separable.—On a double nitrite of ruthenium and potassium, by M. L. Brizard. The new salt described has the composition $Ru_2H_2.(NO_2)_4.3KNO_2.4H_2O$. On the reducing properties of boron and aluminium, by MM. Duboin and Gauthier.—Oxidation of propylglycol by bromine water, by M. André Kling. By the reaction of bromine upon propyl-glycol,

$$CH_3.CH(OH).CH_2OH$$

in sunlight, an appreciable amount of acetol,

$$(CH_3.CO.CH_2.OH),$$

is produced.—On some opium alkaloids, by M. Émile Leroy.—Determinations of the heats of combustion, neutralisation, and solution of codeine, thebaine, papaverine, and narcotine.—On the elimination of nitrogen and phosphorus in infants nourished at the breast, by M. Œchsner de Coninck.—On dichlor-3.4-butanoic acid, by M. R. Lespieau. Of the two possible formulæ for this acid,

$$CH_2.Cl.CH(OH).CH_2.CN \text{ and } CH_2Cl.CH(CN).CH_2.OH$$

experimental evidence is given in favour of the former.—Action of bromine on isobutyl bromide in presence of anhydrous aluminium bromide and aluminium chloride, by M. A. Mouneyrat. Starting with the monobromobutane,

$$CH_3.CH(CH_3).CH_2Br,$$

by the action of bromine in presence of aluminium bromide, four substances are obtained, isobutylene bromide, a tribromoisobutane, boiling at 130° under 26 mm. pressure, tetrabromoisobutane, all in small quantities, and, as chief product, a tribromoisobutane boiling at 112°, probably $CH_3.CBr(CH_3).CHBr_2$.—On the composition of the albumen of the carob bean; production of galactose and mannose by hydrolysis, by MM. Ed. Bourquelot and H. Hérissey.—Experiments on the state refractory to the serum of the eel, by MM. L. Camus and E. Gley. The natural immunity of the hedgehog to the poisonous action of eel serum is now shown to be also possessed by other animals, such as the common frog, toad, chicken and pigeon. This immunity, which the authors have shown to be due to a specific resistance of the red blood corpuscles, is called by them cytologic immunity, to distinguish it from the humoral or acquired immunity resulting from the production of antitoxin in the immunised animal.—Experimental researches on an agglutinine produced by the albumen gland of *Helix pomatia*, by M. L. Camus.—Intra-uterine transmission of vaccinal immunity and the antivirulent power of the serum, by MM. Beclère, Chambon, Ménard, and Coulomb.—On the branchial respiration in Diplopods, by M. M. Causard.—On the breccias of the Briançonnais, by M. W. Kilian.—On a bathymeter founded upon the use of Crusher cylinders, by MM. Charbonnier and Galy-Aché.

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THURSDAY, AUGUST 10, 1899.

## FLORAS FROM THE ROYAL GARDENS, KEW.

*Flora Capensis: being a Systematic Description of the Plants of the Cape Colony, Caffraria, and Port Natal (and Neighbouring Territories), by various Botanists.* Edited by W. T. Thiselton-Dyer, C.M.G., C.I.E., LL.D., F.R.S., &c., Director, Royal Gardens, Kew. Published under the authority of the Governments of the Cape of Good Hope and Natal. Vol. VI. Hæmodoraceæ to Liliaceæ. Vol. VII., Parts I. and II. Pontederiaceæ to Gramineæ. (London: Lovell Reeve and Co., 1896–97.)

*Flora of Tropical Africa.* Edited by W. T. Thiselton-Dyer, C.M.G., C.I.E., LL.D., F.R.S., &c., Director, Royal Gardens, Kew. Vol. VII. Hydrocharideæ to Liliaceæ. Published under the authority of the First Commissioner of Her Majesty's Works and Public Buildings. (London: Lovell Reeve and Co., Ltd., 1898.)

IT should not be necessary at this time of day to emphasise the fact of the imperial character of the Royal Gardens, Kew, still it would appear there are many inhabitants of Great Britain whose notion of the value of this establishment is limited by their desire for a local public park suited to the recreation of dwellers in and about London. Several incidents have of late shown this—witness the recent preposterous proposal brought forward in the House of Commons to throw the gardens open to cyclists! Suggestions of this kind are on the face of them, to those aware of the true character of the gardens, too absurd for discussion, yet there is an element of danger in this appeal to the selfish instincts of that large body of pleasure-seekers who are veritable Gallios in their contempt for science, especially when its just claims place an obstacle to the gratification of their pleasure whims. It is hardly conceivable that any First Commissioner of Works—and he is the Minister responsible for the gardens—would ever assent to such modification of the traditional character of the gardens as concession to the demand above referred to, which may be taken as symptomatic of a craze, would mean; yet in these days of political opportunism, and with a prospect of its even greater development, the preservation of the noble heritage the nation possesses in the Kew of the present becomes a question not altogether free from anxiety in the minds of those who know the services Kew renders and is capable of yet rendering to the Empire. Perhaps the surest way of avoiding disaster in the future is by making known far and wide what are its real functions and how they are discharged, for through the education of public opinion alone can an effective checkmate be given to any movement destined to sacrifice the scientific features of Kew at the altar of popular pleasure.

It is not the intention to discuss here the whole of the functions that belong to and are discharged by Kew—its value as an unrivalled microcosm of the vegetation of the world, its example as a school of horticultural practice, its position as a training ground for young gardeners, its use as an index of the products of the vegetable kingdom and as a nursery and centre of distribution of economic plants for the benefit of our Colonies—but to direct attention to the continued progress, indicated by the titles of the volumes cited above, of the large undertaking to which the energy and foresight of its first Director, Sir William Hooker, committed Kew—namely, the issue of a "Series of Floras" under the authority of the Home or Colonial Governments. Botanists are familiar with what has been already done by Kew towards the carrying out of this programme. The Australian Flora by Bentham and Von Mueller, that of Hong Kong by Bentham, of New Zealand by Dr. Hooker, of Mauritius and the Seychelles by Baker, of the West Indies by Griesbach, and the recently completed British Indian Flora by Sir Joseph Hooker are a tribute alike to the industry and talent of the botanists who have taken part in their production and to the importance of Kew in focussing botanical knowledge, as well as to the labours of our countrymen in the exploration of regions opened up to our occupation. The appearance of the volumes mentioned above has been particularly welcome, inasmuch as they denote a renewal of progress after a pause. The Flora Capensis was arrested after the publication of the third volume in 1865 by the death of Harvey, who, with Dr. Sonder, was its principal author; and of the Flora of Tropical Africa, the last of the three volumes brought out by Prof. Oliver appeared in 1877. The Director of Kew is to be congratulated upon having surmounted the hindrances which have contributed to the delay in continuing these Floras, and he will, it may be hoped, be encouraged to contend with and overcome all obstacles that may as it seems, threaten a steady advance to the conclusion of the works.

The volumes and parts before us are not in sequence with the volumes that have already appeared. As Sir William Thiselton-Dyer points out, once the plan of a work of the kind is settled it is immaterial what part first appears, and he has exercised a wise discretion in giving early attention to those groups of plants which are abundantly represented in our gardens, and which have consequently compelled special attention on the part of members of the Kew staff. The Monocotyledons have been therefore selected for first treatment in the resumed work upon the Floras, and we have the benefit of the ripe experience of Mr. Baker in the elucidation of the Liliaceæ, Irideæ, Amaryllideæ and allied orders, which are so popular in horticulture and form so large an element of the plant-life of South Africa, and to a less extent in the area embraced within the scope of the Tropical African Flora; Mr. Rolfe brings to the enumeration and description of the Tropical African Orchideæ a rare knowledge of the order; and Mr. N. E. Brown describes the Tropical African species of Disa as an expert. Tropical African Hydrocharideæ have fallen to the share of Mr. C. H. Wright, and the Cyperaceæ of South Africa find a sound critical exponent in Mr. C. B. Clarke; the account of the Gramineæ of the same area is in the able hands of Dr. Stapf, and should be completed in the next part of the Flora, for which we trust we shall not have long to wait.

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In the continuations of these Floras we have the same standard of excellence to which preceding volumes have accustomed us, and which we therefore look for in publications coming from Kew. Their issue will be a boon not only to the professed botanical world, but also to all those who are interested in the many plants now known in, and still coming into cultivation from, Africa ; and they should give a great stimulus to the further investigation of the vegetation of Africa and to the introduction of interesting and beautiful plants to the horticulture of the world.

No one looking at these volumes can fail to notice that their production at Kew, where a collection of living plants in a garden is associated with one of dried specimens in a herbarium, gives additional value to them. The necessity of the latter as a guide to the accurate determination of the nomenclature in a scientific garden is apparent ; the service of the former as an adjunct to the herbarium by affording means for the study of the living plants in cases where the dried specimen can seldom be satisfactory is clearly brought out in the account of the groups of succulent monocotyledons treated of in these Floras. If all descriptive botanists were able, as is possible at Kew, to look at the dry bones of the plants with which they deal with some consideration of the form that clad them when alive, we should be spared much of that prolific synonymy which is the bane of the systematist. It is the possession of the finest collection of living plants along with a like one of dried specimens, through which it can contribute as in these Floras to the advance of our knowledge of the vegetation of the globe, that gives Kew an absolutely unique position as the leading botanical institution of the world, a position it has achieved in little over fifty years through the scientific ability and remarkable administrative capacity of its successive Directors, Sir William Hooker, Sir Joseph Hooker, and Sir William Thiselton-Dyer.

## *STATISTICAL METHODS APPLIED TO BIOLOGY.*

*Die Methode der Variationsstatistik.* Von Georg Duncker. Pp. 75, with 8 figures in text. (Leipzig : Wilhelm Engelmann.)

THIS pamphlet, a reprint from the *Archiv für Entwickelungsmechanik*, is an attempt to render the formulæ and results of the statistical method somewhat more accessible to German biologists than they are, for example, in Prof. Karl Pearson's original papers. In the first part a complete outline is given of the fitting of frequency curves, normal or skew, to observed statistics, and in the second part a similar outline of the theory of correlation. The whole of this extensive ground is covered, however, in some sixty octavo pages, necessitating a degree of compression too great for satisfactory results. Proofs are necessarily almost wholly omitted, several difficulties likely to occur to beginners are slurred over, and there is more than one absolute blunder.

If $y = \phi(x)$ be any frequency curve, the frequency of deviations lying between $x - \frac{1}{2}c$ and $x + \frac{1}{2}c$ is given by the integral of the frequency-function $\phi(x)$ between those limits. If, and only if, $c$ be very small, we may replace this integral by the product $y.c$ to a close degree of approximation. Hence, in any practical case of recording the distribution of frequency where we have to choose an arbitrary unit of grouping $c$, this should always be made as small as possible. If this be done, and if the number of observations be large, the observed frequency polygon closely approximates to a continuous curve, and the element of area round any ordinate differs very slightly from $y.c$. Moreover, the process of obtaining the moments of the observed frequency polygon by treating the observed frequencies as isolated loads, then differs very slightly in result from the process of continuous integration by which the moments of the theoretical curve were calculated. But if the element of grouping be not small, the element of area round $y$ may differ very sensibly from $y.c$, and the process of calculating moments by treating group frequencies as isolated loads is not even a rough approximation to continuous integration. Hence Prof. Pearson's original preference of the moments of the trapezia system (*Phil. Trans.* A, 1895, "On Skew Variation," &c.), and Mr. W. F. Sheppard's papers on moment calculation (*Proc. Lond. Math. Soc.*, vol. 29, and *Journal Roy. Statistical Soc.*, vol. 60, 1897). This difficulty, due to the grouping, is entirely passed over by Herr Duncker. A series of observations giving only five base elements $c$ is fitted without remark to a normal curve (Fig. 2). In every case the ordinates of the fitted curve are calculated only for the abscissæ of the observed ordinates, their tops are joined up, and the polygon so obtained called the "theoretical frequency polygon," as in Figs. 1, 2, 3—a procedure of somewhat dubious use in any case, and quite illegitimate where the elements are as large as in Fig. 2. If the author had not missed this fundamental point he would not, perhaps, have been so puzzled by Prof. Pearson's use of first one and then another method of calculating moments. It is a pity that all the arithmetical examples given of fitting frequency curves refer to cases of discontinuous variation, as these are naturally the material least suitable for representation by continuous curves.

There seems a corresponding lack of clearness in some fundamental points of the theory of correlation. The various formulæ for correlation coefficient, regressions, &c., are given, but the author nowhere clearly points out their meanings and limitations in cases of non-normal correlation. It is not noted that for complete independence the condition $r = o$ is, in general, necessary but *not sufficient*. The values of partial correlations are given, but it is not noted that only in normal correlation (so far as we know) is the partial correlation the same for every array. The correction given on p. 48 for reducing the product sum about an arbitrary pair of axes to the product sum about the mean is surely absolutely wrong ; the different sums given are all of different dimensions. If $S_0$ be the value of the sum for axes through the mean, $S_1$ its value for the arbitrary axes

$$S_0 = S_1 - N. \bar{x}\bar{y},$$

where N is the number of observations and $\bar{x}\bar{y}$ are the coordinates of the mean with reference to the arbitrary axes. Of course this expression, and method of getting $S_0$, is quite well known, not novel as Herr Duncker seems to think.

Again, complete correlation does not subsist only when "every single deviation of the one characteristic corresponds to a precisely equal deviation of the other" (p. 43), but whenever the deviations are in any constant proportion. This definition, moreover, ought only to be held to apply to the case where the means of arrays lie on straight lines.

We do not like the definition of correlation as a "Beziehung . . . welche bewirkt. . . ." This is not a statistical definition, and confusion arises if the word be used carelessly, sometimes in one sense and sometimes in another. The definition of the correlation coefficient on p. 54 is much better; but why does the author call it a "morphological definition"? It is purely statistical.

The statement that it is mainly correlation which maintains the type ("die Korrelation ist es hauptsächlich, welche den Typus einer Formengemeinschaft aufrecht erhält") is a very pretty error; possibly due to the fact that biologists use correlation in a more "intensive" sense than statisticians do. Statistical correlation has absolutely nothing whatever to do with the maintenance of type. The type is described by the coordinates of the mode. If $X_0$ be the modal size of any organ in a parent, $Y_0$ the modal size of the same organ in the offspring, the "type is maintained," or constant, whenever

$$X_0 = Y_0,$$

and this relation is quite independent of the correlation. The correlation between parent and offspring might be absolutely zero, *i.e.* every single parent's offspring might be a fair sample of the whole population, and yet the type might remain absolutely fixed; or, on the other hand, parent and offspring might be perfectly correlated, and yet the type change entirely. This is at least *formally* possible. Thus, in the extreme case of alternating generations A B A B . . ., there might in the statistician's sense be perfect correlation—perfect inheritance—between A and B, although A and B differ absolutely.

Of course in a work of the present kind, written chiefly for drawing attention to the work of others, one does not look for much that is original. There is a curious approximate relation given by the author between geometric mean, arithmetic mean, and standard deviation (p. 38), a relation discovered empirically and given without proof. If

$G$ = geometric mean,
$M$ = arithmetic mean,
$\sigma$ = standard deviation,

then *approximately* in many cases

$$\sigma^2 = M^2 - G^2.$$

The relation depends solely on all deviations being small compared with the mean, and admits of a simple algebraical proof.

Amongst small points we have marked, we would like the term "individual" variation suppressed, as it is frequently misleading, and surely not equivalent to "spontaneous"; the word "variant" seems to us unnecessary and misleading in the case of continuous variation where arbitrary groupings are used; the distinction between "Rasse" and "Formeneinheit" (p. 17) (". . . erstere nothwendig in mehreren Merkmalen, letztere in einem einzigen differiren") is surely inadequate; a preliminary calculation of the mean before calculating the moments of a frequency distribution (p. 18) is quite unnecessary, as the mean is given by the first moment; and the author is unfortunately in error in ascribing to the present writer (p. 52) the extension of the formulæ of correlation to several variables.

We regret that this notice has had to be for the most part fault-finding, as the author has undertaken a useful and somewhat thankless task, and we believe that, notwithstanding our criticisms, the pamphlet will be useful in extending a knowledge of the statistical method in Germany. There is a bibliography of 111 items at the end of the pamphlet, a feature which will render it useful to English readers as well as German. We are, of course, in sympathy with the author's aim, and hope he may have the opportunity of revising some of the points we have noted in a second issue. G. U. Y.

## TEXT-BOOKS OF PHYSICS.

*Physics, Experimental and Theoretical.* By R. H. Jude and H. Gossin. Pp. xiii + 926. (London: Chapman and Hall, Ltd., 1899.)

THE increasing study of science in schools has been the cause of a considerable crop of text-books of elementary physics, but there is still the want of a more advanced book on the subject. This want Mr. R. H. Jude has endeavoured to supply, and as far as can be judged by a glance through his book, supplemented by a more careful examination of a few chapters, he has succeeded in giving us what promises to be a very useful work both to teachers and students. Experience only can show whether he has hit on the right standard of difficulty, and whether the learner will find the explanations sufficiently clear and complete; but there seems no reason to doubt it, considering that the work is an English adaptation of a book by Prof. Gossin, which is apparently much used in France.

Originally intended to be a translation, the volume before us contains many new articles and chapters, and the translated portions have been amplified. The first volume treats of mechanics, heat and sound. The following remarks are not intended to be special criticisms of this particular book, but rather are suggested by it and put down as matters for consideration, being of general interest to teachers of science.

It seems a little doubtful to me how far a book which contains a somewhat advanced treatment of experimental physics should enter into questions of elementary mechanics. It is impossible to believe that a student who can follow the method of treatment given in the chapters on heat in this volume should not be familiar with the parallelogram of forces, and the construction of the common pump. Some portions of dynamics, such as moments of inertia, must, of course, be included, and it may be argued that it is better to present a complete than a partial statement of mechanical principles. This is true, and of course a good deal might be said about the parallelogram of forces and velocity that is worth reading at any stage in a student's career, but what strikes me in this volume is that the standard of treatment does not quite correspond,

and that a book which enters into questions of entropy and thermodynamic relations might pass a little more rapidly over baby mechanics. This remark applies specially to the illustrations, some of which are of the most elementary character and even childish.

This brings me to the second point I wish to submit to the consideration of authors. A number of illustrations in modern books seem to me to be put in for the sake of interrupting the text by a picture rather than for the sake of explanation. There is, for instance, the usual illustration which pretends to illustrate the fact that all bodies fall in vacuo with the same velocity. A long glass tube with a tap at the lower end, two hands holding it, and about a third of the way downward a small black dot and another dot a little bigger about a millimetre higher up. I suppose that the dots represent bodies, and that their closeness is intended to show their falling together. Unfortunately, in the present instance the stopcock at the bottom is open according to English ideas (though closed if they mean to be French taps), so that the intelligent student unacquainted with the habits of the French plumber would carry away the idea that bodies fall together in air at atmospheric pressure. But without laying stress on this, I should like to know the opinion of my colleagues, whether they seriously believe that students are assisted by illustrations of this nature. Some psychological freak may account for its being so; but it seems odd to me, and is worth investigating. I have marked several other instances of illustrations which seem to me to be of the same type. On the other hand, the diagrams illustrating graphic methods in thermodynamics are clear and well chosen.

Finally, I am not quite sure I like the introduction of exercises and examples. Examinations, no doubt, are a necessity, and I have no objection to books written specially to push boys through them, but the present book is too good to serve in this manner, and one does not quite like being constantly reminded of the fact that ninety-nine per cent. of students only study physics because they are obliged to do so, and I have never yet seen a student, or seen any one to my knowledge who knows a student, who will work through an example without the stimulus of examinations upon him. I should prefer to see the examples collected in a special appendix at the end. Two small points I may draw attention to, as the author may wish to correct them in another edition. Speaking of solar heat, Lord Kelvin's theory of falling meteorites is mentioned, but nothing is said about the now generally accepted theory of Helmholtz that the sun's contraction by his own gravitation is sufficient to account for the keeping up of his temperature.

Speaking of the fact that the surface of liquid at rest is a horizontal plane, the author considers it in § 127 to be a sufficient proof that the image of a plumb line is observed to be a prolongation of the line itself, for it is said that "an object and its image are symmetrical only when the reflecting surface is plain." Will not a spherical surface do equally well, if the plumb line passes through the centre of the sphere? If I add that in the figure on p. 108 the meniscus of a mercury column is wrongly drawn, inasmuch as its curvature diminishes as it approaches the glass sides, I have exhausted all the blemishes which the critical mind can discover. But I started to praise rather than to criticise, and must conclude with the hope that the volumes on light and electricity will soon be ready for publication.

ARTHUR SCHUSTER.

## OUR BOOK SHELF.

*The Tides Simply Explained: with Practical Hints to Mariners.* By the Rev. J. H. S. Moxly, B.A., T.C.D., Chaplain to the Forces; Chaplain to Chelsea Hospital. Pp. viii + 151. (London: Rivingtons, 1899.)

THIS is a paradoxical work which may do harm owing to the standing of its author. He openly avows himself at war with the scientific world:—

"What is this strange hallucination that has taken possession of the minds of great mathematicians? I have quoted several truly absurd statements and arguments of our teachers in my first chapter. I wished to show my readers, by many infallible proofs, that the idols of authority, to which we have been bowing down, are not the correct thinkers we have supposed them to be" (p. 58).

He could not be much more severe if scientific men were a general-staff. His method of "infallible proof" of the fallibility of these idols is simple; he quotes a sentence or a paragraph, and then says:

"This is, of course, sheer nonsense! It is too absurd a statement to deserve any answer" (p. 8).

Having disposed of existing theories by this drastic process, he proceeds to give his own theory of the tides:

"The moon and earth are being drawn together by the attraction of gravity, yet they do not come together. There must therefore be a force equivalent to the force of attraction, but acting in an exactly opposite direction, which keeps the earth and moon asunder. It does not matter what we call it! 'Centrifugal force' will do for a name for it, if you like. The point for us is that the force does exist—must exist, and that it is exactly equal to the attractive force, but opposite in direction. *Well, then, if the attractive force raises a tide under the moon, the force opposite the attractive force will produce a similar effect on the opposite side of the world*" (p. 52).

The sentence in italics (which are mine) is one of the neatest things in paradox I have come across. It is scarcely surprising that the man who could invent it should be able to deduce from this amazing premiss the correct expressions for the tide-generating force at any point on the earth's surface. But then he throws this advantage to the winds, by despising the horizontal component as insignificant, and electing to work with the vertical component only, because it suggests to him an attractive but hopelessly false analogy. We are to imagine a gigantic power taking the world in its grasp, as a schoolboy would squeeze a ball between his finger and thumb. The horizontal component of tide-generating force is compared to a butterfly harnessed to Nelson's Column; but, to suit his own ideas as regards vertical force, Mr. Moxly makes the butterfly a schoolboy and Nelson's Column an india-rubber ball.

After stating this general theory, Mr. Moxly examines some cases of what have been unfortunately called "abnormal" tides, and triumphantly gives explanations of them; partly wrong, and partly such as any one could deduce from a general knowledge of the locality; and, as this is done with some skill, it is to be feared the book may mislead some of the "mariners" to whom it is addressed. It is to be hoped that before trusting Mr. Moxly they will wait until he has produced detailed and successful tide-tables for any given port deduced fairly from his own theories.

H. H. T.

*Defective Eyesight.* By Dr. D. B. St. John Roosa. Pp. ix + 186. (New York: The Macmillan Co. London: Macmillan and Co., Ltd., 1899.)

Dr. Roosa's book is pleasantly written and easy to follow, but it is not very clear what particular place in ophthalmic literature the book is intended to occupy. From the superficial manner in which each subject is treated it would appear to be intended for the instruction of the junior student.

But a student's manual on the refraction of the eye in which no mention is made of retinoscopy, and the ophthalmoscope is only casually referred to as being unnecessary in most refraction cases, is certainly somewhat incomplete.

Most people will agree with Dr. Roosa in condemning the permanent wearing of prisms in the treatment of heterophoria. But the statement that want of balance of the external ocular muscles never causes asthenopic symptoms, is contrary to the experience of the majority of ophthalmologists.

We thoroughly endorse the author's views as to the practical value of the ophthalmometer, though he overstates the case when he says that, to a competent observer, no mistake is possible in the estimation of astigmatism with this instrument. Those who have used both ophthalmometric and other methods with the same patient, in any considerable number of cases, will agree with Adolphe Javal, jun., that corneal astigmatism often differs from the total astigmatism by 0·5 to 0·75 dioptre.

*The Lancashire Sea Fisheries.* By Charles L. Jackson, M.I.C.E., &c. Pp. viii + 85. (Manchester: Heywood and Son, 1899.)

This is a reprint of a lecture delivered in the Chadwick Museum, apparently under the auspices of the Bolton Corporation. It is full of obvious inaccuracies, is hopelessly out of date, and contains on nearly every page cheap sneers at "pure science" and "the scientists," as opposed to the "business" and "practical men." There is a good deal about "Dame Nature" and "Old Ocean," and "the Great Author of the Universe," with whom the author of the book seems to be on curiously confidential terms. This is a work which, if taken seriously, is calculated, we fear, to do much harm—not to the County Council against whose labours it is directed, but to the fishermen in whose interests it professes to be written—by stirring up bad feeling, class prejudices, and opposition to constituted authority.

*A Country Schoolmaster, James Shaw, of Tynron, Dumfriesshire.* Edited by Robert Wallace. Pp. xcvi + 392. (Edinburgh: Oliver and Boyd. London: Simpkin, Marshall, and Co., Ltd., 1899.)

We have first a sketch of the life and work of James Shaw; but the bulk of the book is occupied with reprints of some of his more characteristic literary productions. These are upon a great variety of subjects, mostly connected with natural history. The early years of James Shaw's life were spent as a pattern designer and calico printer, and it was not till he was over thirty years of age that he became the schoolmaster at Tynron, a country parish in Dumfriesshire. He continued there for thirty-four years. In the early part of his career his tastes were chiefly literary, and he acquired considerable power as a writer both of prose and verse. After he became a country schoolmaster he devoted himself entirely to natural history and archæology. His papers collected in the present volume are of real interest, and charmingly written. After looking through them we feel the justice of his friend's remark: "Shaw was a large man, fated to play out his life-drama on a small and dimly-lighted stage."

## LETTER TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* Nature. *No notice is taken of anonymous communications.*]

### Apparent Dark Lightning Flashes.

Last night during a thunderstorm of rare severity in which brilliant flashes—single, double, triple, or quadruple—followed one another at intervals often of not more than a few seconds of time, I was surprised to see with great vividness, on a suddenly illuminated sky, two nearly vertical lines of darkness, each of the ordinary jagged appearance of a bright flash of lightning. I remembered to have seen two real flashes of just the same shapes and relative positions, and I concluded that the black flashes were due to their residual influence on the retina. I turned my eyes quickly from the dark sky outside to an illuminated wall inside the house, and I again saw the same double dark "flash," which verified my conclusion in an interesting manner. The fatigued part of the eye failed to perceive the sudden brightness of the sky in the one case and of the wall in the other.

Aix-les-Bains, August 7. Kelvin.

## MEETING OF THE BRITISH MEDICAL ASSOCIATION AT PORTSMOUTH.

A goodly number of members of this pre-eminently practical Association journeyed last week to Portsmouth to be present at the sixty-seventh annual meeting. The place of meeting was not so attractive as last year, and perhaps on this account the attendance was somewhat smaller. The subject-matter, however, at Portsmouth was quite as interesting as that at Edinburgh; and those who, braving almost tropical heat, were diligent in their attendance at the meetings got their reward, and will return home with ample food for thought.

After an eloquent and interesting address from the President, Dr. Ward Cousins, in which a sketch was given of the progress made in medicine and surgery during the present century, the meeting divided itself up into sections, and settled down to work.

*Section of Medicine.*—An address on medicine was delivered by Sir Richard Douglas Powell, his subject being recent advances in practical medicine. Under this heading various points of practical interest were discussed. The use of the binaural stethoscope received some attention, the author somewhat deploring the decadence of the old rigid stethoscope, a flexible instrument being incapable of transmitting tactile impulses. Under the head of "Anomalous Fevers," Sir Richard discussed shortly the important subject of mixed infection. The value of what was said on serum therapy was enhanced by the addition of a table indicating the actions of the various sera. Under the "Prevention and Treatment of Tuberculosis" the vexed question of the influence of heredity was considered, the author apparently attaching more importance to this influence than recent investigations would seem to justify. The address concluded with a few suggestive hints concerning a possible preparasitic existence of the tubercle bacillus.

At the opening of the section, the President, Dr. Mitchell Bruce, made a few introductory remarks with regard to the subjects of discussion, viz. the tests for admission into the public services, and Tuberculosis. Sir Dyce Duckworth's paper upon the former subject, in his unavoidable absence, was read by the President. The paper comprised a valuable critique of the methods of examination at present adopted by the public services, and a consideration of the causes and rejection of defective candidates. An animated discussion followed this paper. Prof. Osler advocated that the physical examination of candidates should take place earlier in the course of their training, and alluded to the more common causes of, according to him, unnecessary

rejection. Dr. Wallace discussed the matter from a civil standpoint, and advised the forming of a definite standard of physical fitness. Dr. W. Turner drew attention to the mental condition of candidates, and to the not uncommon occurrence of insanity during active service. The result of the discussion was that the following resolutions were sent up to the Council with a request that they be submitted to the War Office: (1) That the physical examination should precede the educational; (2) that soldiers should not serve in the tropics till twenty-two; (3) that the question of the physical standard should receive reconsideration.

A number of papers, which provoked some discussion, upon the ever-present subject of uric acid and gout followed.

*Section of Surgery.*—An address in surgery was delivered by Dr. Ogston, the medical services of the army and navy forming the subject. The author dealt at length with the unsatisfactory condition of the services, both from the point of view of the medical man and the soldier. During the last three decades the class of medical man aspiring to enter the services has very much depreciated, a fact greatly to be deplored. Further, the medical services are undermanned, and there is a want of adequate training. The Indian Medical Service is, to some extent, an exception, and offers many more advantages than the army and navy. The author indicated generally some lines of remedy for the present regrettable condition of the medical services, and contrasted the methods used by the authorities here with those used abroad, notably in Germany, Russia and France.

The president of the section, Mr. Butlin, delivered a short address on the work of the section. The two special subjects for discussion in this section were (1) the diagnosis and treatment of gunshot wounds of the abdomen, and (2) the prevention and treatment of syphilis in the army and navy.

*Section of Obstetrics and Gynaecology.*—The President of this section, Dr. Granville Bantock, delivered an address in which he urged that in gynæcological cases a more conservative attitude might be adopted, and that a diminution in the number of operations performed might with benefit to the patients take place.

An interesting discussion subsequently took place upon fever following delivery, with special reference to serum therapy. The discussion was opened with a paper by Dr. Herbert Spencer. With regard to the serum treatment the author remarked that a large number of observations had now been made upon this subject, 350 cases having been collected by a committee of the American Gynæcological Society. Among these cases there was a mortality of 33 per cent., but the natural mortality of the diseases was probably not greater than this. Little more can be said for this treatment in this class of case than that it somewhat ameliorates the severity of the disease.

*Section of State Medicine.*—Dr. George Wilson delivered the presidential address in this section. The author discussed the relation of bacteriological research and methods to preventive medicine.

*Section of Psychology.*—Dr. Nicolson dealt with the interesting question of the reproachable differences of medical opinion in lunacy cases, and whether they could be avoided. Differences of opinion among medical men were not uncommon in (1) ordinary lunacy cases, (2) civil cases, (3) non-capital criminal cases, and (4) capital criminal cases. In the case of criminal cases, malingering formed a most puzzling element. The author laid stress upon the fact that, although anthropological measurements afforded very valuable information and were to be encouraged as likely in the future to be capable of formulating rules of value, too much stress with regard to individual cases should not be placed upon them. An active discussion followed this paper.

*Section of Anatomy and Physiology.*—The presidential address in this section was delivered by Dr. Charles. The lecturer dealt with the advancement which had recently been made in physiology. He noticed with pleasure that now in this country physiology numbered amongst her votaries a number of accomplished organisers and able laboratory workers, and that we had not now to reproach ourselves with neglecting what Du Bois Reymond rightly called the queen of the natural sciences.

Mr. Stanley Boyd read a paper on the interaction between the ovaries and the mammary glands. This interaction, he remarked, in the cases of removal of both ovaries caused an apparent subsidence and retrogression of cancerous growths in the breast.

*Section of Pathology.*—Dr. Payne delivered the presidential address in this section. A discussion followed upon ulcerative endocarditis.

*Section of Pharmacology and Therapeutics.*—The President, Dr. Bradbury, in opening the work of this section, referred to the difficulty in fixing the place of pharmacology in the medical curriculum. He considered an accurate knowledge of pharmacology to be essential to the practitioner of medicine.

The work of the section began with a paper by Dr. Lauder Brunton on headaches. The paper contained a mass of valuable and interesting information, and comprised a consideration of the *rôle* played by vaso-motor changes in the causation of headaches, and also that played by toxæmic conditions and errors of refraction. The treatments of the different forms of headache were considered, and many useful hints as regards their prevention were given. A discussion followed. Upon replying, Dr. Brunton mentioned that altitudes and depths probably produced headaches by altering the atmospheric pressure in the sinuses.

*Section of Laryngology and Otology.*—The President, Mr. Creswell Baber, delivered an address on the progress of rhinology during the last thirty years.

The section of Tropical Diseases was well attended. Dr. George Thin gave an able address, in which he referred to recent researches on the extra corporeal life of the malarial parasites. The President, after having regretted the unavoidable absence of Major Ross, began to discuss the teaching of tropical medicine. The author dwelt at some length upon the advantages of Netley as affording more material than any other institution for the teaching of tropical medicine, and showed diagrams comparing Netley with London and Liverpool as regards the number of patients available for instruction. According to the author, the advantages possessed by Netley were very great, especially with regard to hepatitis and hepatic abscess.

The museum of the Association, always a prominent feature of the annual meetings, was well filled with exhibits, and was much patronised by members.

*Nunquam animus motu vacuus est.* Absolute rest is a myth of the consulting room often prescribed but rarely practised. It, along with the Salisbury diet and other things, is what one expects of one's friends but not of oneself. The hard-working medical man doubtless wants absolute rest badly enough, but by prefixing his holiday with an attendance at the annual British Medical Association meeting he acts wisely. There work is so mixed up with pleasure that one passes almost insensibly from the one to the other, the meetings forming as it were an intermediate region between work and holiday, shading off the contrast between the two, making the loss of constant occupation less acute, and helping one to slip easily into the *dolce far niente* which one has earned so well.

F. W. TUNNICLIFFE.

## THE RELATION OF MOTION IN ANIMALS AND PLANTS TO THE ELECTRICAL PHENOMENA ASSOCIATED WITH IT.[1]

THE lecturer began by observing that the proper subject of the lecture being "the nature or laws of muscular motion,"[2] he would discuss the chemical, mechanical and electrical concomitants of this most important function with a view to the elucidation of their mutual causal relations. He would, however, ask the attention of the Society chiefly to the *electrical* phenomena which are associated with muscular action, as being those which he had himself specially studied. Some points relating to the *mechanical* effects of muscular action must be referred to by way of introduction, inasmuch as it is by these that a muscle performs its function as an organ of motion. There were two ways of investigating these effects experimentally. We might observe and record either the change of form which a muscle undergoes in response to a stimulus of very short duration when contracting isotonically, *i.e.* as it does when lifting a weight, or the increase of tension which occurs when it endeavours to overcome a resistance, *i.e.* when it acts isometrically. It was shown that although, as regards an entire muscle, the isometric method was preferable to the isotonic, the time occupied by a single element of muscular structure when directly excited in developing its maximum tension (*i.e.* in the transformation of chemical into mechanical energy) could be best estimated under isotonic conditions. He then proceeded to describe his own method of accomplishing this measurement with the aid of photography. It consists in observing the change of form of the surface of a living muscle when a single break induction current is led through it in such a way that the observed surface is at the kathode. A magnified image of the kathodic electrode, which moves freely with the muscle, is projected on a slit behind which a sensitive plate passes, and in this way a curve is obtained from which the time-relations of the movement can be deduced. It is thus learned that at the kathodic spot, *i.e.* at the spot immediately excited, the process attains its greatest activity before the end of the first hundredth of a second. The importance of this datum consists in its bearing on the question whether or not the electrical change by which the change of form thus observed is accompanied is coincident with it, follows or precedes it. The answer to this question could not, of course, be given until the time-relations of the electrical change had been considered. These were discussed as follows:—

The essential point in investigating the *electrical* changes which occur in muscle is to connect two parts of its surface through a galvanoscope. The general result of such an exploration is (1) that similar parts in a similar physiological state are equipotential; (2) that between similar parts which are not in the same state there is always a difference of potential, measurable by the method of compensation, the less capable of function, *i.e.* the less living, being negative to the more living; and (3) that transitory differences of potential arise between two parts of the living surface when the one is excited to discharge of function, the other remaining at rest. Thus the state of rest or fitness for function of a part is denoted by relative "positivity," discharge of function by relative "negativity."[3]

[1] Abstract of the Croonian Lecture, delivered before the Royal Society, by J. Burdon-Sanderson, M.A., M.D., F.R.S., on March 16.
[2] See "The Record" of the Royal Society, 1897, p. 126.
[3] The use of these words in the sense above stated has been strongly objected to. It is difficult to see to what obscurity of meaning it can give rise. "Negativity" of a surface means nothing more than it is negative *relatively* to another surface.

*First Fundamental Experiment.*—The effect of an excitation which is instantaneous and so localised as to affect in the first instance only one of the two surfaces of contact is the sudden manifestation of a difference of potential between them, this effect being momentary (case 1) or continuous (case 2) according to the duration of the excitation. In either case it is designated "excitatory variation" if the muscle is referred to, *or* "action current" if the galvanoscope is referred to.[1] If the capillary electrometer is used as galvanoscope, and its excursions are recorded photographically, the curves so obtained truly and faithfully express to us the character and time-relations of the *variation*, provided only that we know according to what rule they are to be interpreted. This rule can be deduced from the well-known properties of the instrument, as has been fully set forth elsewhere.[2] We may, however, interpret the photographic curves we obtain in the exploration of living muscle by *comparing* them with counterparts photographed under previously determined and known physical conditions. Thus by arranging our physical experiment so as to reproduce the hypothetical conditions of our physiological one, we may prove the truth of our hypothesis by the coincidence of the two results. And inasmuch as the two cases, *i.e.* the two forms of "variation," above referred to, are the only ones that present themselves, provided that we adopt a mode of procedure to be presently explained, there is no difficulty in applying this purely empirical procedure.

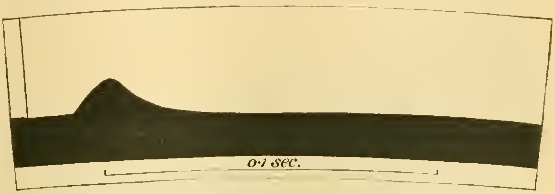
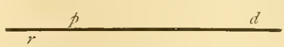



FIG. 1.—Photographic curve of diphasic variation of sartorius muscle. Rate of movement of plate indicated by distance accomplished in 1/10 sec.; moment of excitation by vertical (radial) line.

The first fundamental experiment is one in which a curarised muscle of simple structure (*i.e.* one which consists of a band of parallel fibres) is subjected to the action of an instantaneous stimulus applied to it near one end, as shown below. The result is that a wave of excitation,




of which the progress is marked by mechanical and electrical changes, passes along each fibre (represented by the black line), starting from the seat of excitation $r$, and affecting first the nearest contact $p$, and after an interval the more distant contact $d$. The photograph (Fig. 1) is the curve obtained under these conditions. But if, as above suggested, we proceed in such a way as to limit the observation to what happens at one contact only, and for this purpose *cancel* the effect at the further contact $d$, and repeat our photographic observation just as before, we find that the curve has assumed an entirely different form shown in the photograph (Fig. 2). [As in both photographs, the movement of the sensitive plate is circular, the ordinates are polar, and must be measured accordingly.] Before the effect at $d$ was cancelled, the curve had the form shown in Fig. 1. We therefore conjecture that the

[1] Here again our language has been objected to. "Excitatory variation" means the coming into existence of a difference of potential between two surfaces in consequence of stimulation of one or both of them. It is a translation of the German word "Reizschwankung."
[2] *Journal of Physiology*, xxiii. p. 325.

difference of contour between Figs. 1 and 2 represents the effect of the arrival of the wave of excitation at the distal electrode *d*. The proof that this is so is as follows (see diagram, Fig. 3):—From the measurement of the polar ordinates of Fig. 1 we obtain by calculation the curve P′, which represents the change which occurs in the

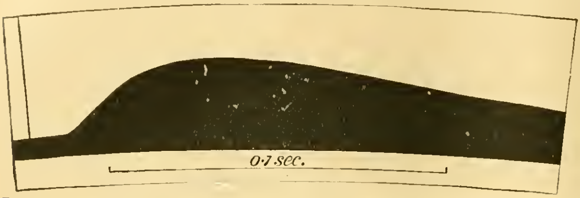



FIG. 2.—The same as Fig. 1 after cancelling the excitatory change at D. (See diagram on p. 343.)

difference of potential between the surface of contact *p* and the rest of the surface of the muscle during the period of excitation.[1] We assume an identical curve D′ in the same relation to the contact *d*, differing from P′ only in the opposite sign of its ordinates, and relating to a period a little (in the case represented 15/1000 sec.) later than of P′; and by summing the synchronous ordinates of the two curves P′ and D′ algebraically, we obtain the curve S′, which expresses what must be the successive differences of potential between *p* and *d* when the effect of the change at *d is not cancelled*. If we deduce this curve by calculation from Fig. 2, the two curves, *i.e.* the deduced curve and the summation curve, ought to coincide. Their actual coincidence shows that the relation between the curves P′, D′ and S′ has been correctly understood; it affords satisfactory proof that from P′ we can deduce S′, and consequently good reason for making the determination of P′, *i.e.* the *monophasic variation*, the aim of our experimental method.

With reference to this method there are two points still to be adverted to. One is that it gives us the means of measuring with great exactitude the rate of propagation of the "excitatory wave," the progress of which from the seat of excitation has been already mentioned, and of proving that, although it varies according to the temperature and the vitality of the muscle, it is, under unchanging conditions, fairly constant. The other point relates to the mode of cancelling the effect of the wave of excitation at the distal electrode. The most effectual and simplest way of doing this is to apply a tight ligature across the path of propagation, the effect of which is to arrest the progress of the wave in its course from *p* to *d*. Another method is to devitalise the part of the muscle to which the distal electrode is applied by heat. The result in the two cases is the same as regards the electrical response to excitation. Fig. 1 is converted into Fig. 2. But as regards the electrical state of the muscle when at rest it is different—*i.e.* when the ligature is applied half-way between *p* and *d* the contacts remain equipotential, or nearly so; whereas in the other case the unexcited and unexcitable dead surface is found to be strongly negative to the other.

We are now in a position to sum up what is to be learned from the first fundamental experiment. The most important result is that, both as regards the muscle when "at rest" and the change of state which is evoked by excitation, the observed instrumental effect depends exclusively on the state of the surfaces of contact, and consequently, when the distal contact is cancelled, on that of the proximal contact only.

*Second Fundamental Experiment.*—We have so far only considered experimentally the effects of a single instantaneous excitation on muscle, causing it to give the mechanical effect known as a twitch. We have now to inquire what are the electrical concomitants of *continuous contraction*. This part of the subject has greater interest than the one we have been considering, inasmuch as it involves the question of the nature of ordinary voluntary muscular action, with reference to which there are reasons for holding that its continuity is apparent only. One of the chief of such reasons is to be found in the supposed resemblance of the sound of a muscle contracting normally to the musical sound of a muscle subjected to a rapid series of instantaneous stimuli. It is ordinarily stated that inasmuch as we can produce continuous contraction by discontinuous stimulation (artificial tetanus), all continuous contraction is so produced. Putting aside the question of muscle-sound, which does not here concern us, and confining ourselves to the electrical concomitants of continuous action, it can be shown that under certain conditions a continuous effect can be evoked by a single uninterrupted stimulus, and that in the nearest approach we can get to natural contraction, the reflex spasm, there is no evidence of discontinuity *in the sense in which this is usually understood*. Let us first see what are the electrical concomitants of artificial tetanus. If the muscle is completely tetanised, *i.e.* subjected to a succession of stimuli at the rate of over 50 per second, the electrometer gives us a curve, of which the general form is shown in Fig. 4. The muscle passes at once from the state of *capacity for action* into the state of *action*. This is indicated by the sudden manifestation of a difference of potential, which persists as long as its cause.

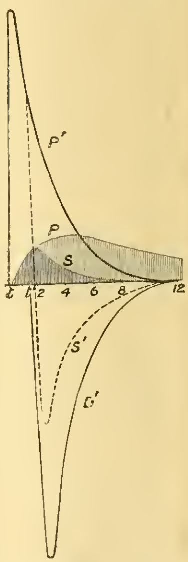



FIG. 3.—Diagram showing the relation between the photographic curves and the curves of difference of potential which they indicate and between the monophasic curves P′ and D′ and the diphasic S′. The numbers below the horizontal line denote hundredths of a second.

When the rate of excitation is less frequent, the electrometer curve gives evidence that the tetanus, whether still mechanically complete, or already incomplete, is composed of a series of twitches, *i.e.* of single monophasic effects. [Photographs were shown of the response in a sartorius, devitalised under the distal electrode, and excited by a series of instantaneous stimuli following each other with a frequency of 60 per sec. in one case, 20 per sec. in the other.]

If, however, while still retaining the higher frequency, we subject the muscle to a series of short tetanising excitations, each lasting say for a tenth of a second or more, and succeeded by a rest of similar duration, we obtain a curve of alternate polarisation and depolarisation such as would represent short, but persisting, differences of potential, alternating with periods of indifference (Fig. 5).

[1] The way in which the curve P′ is deduced is fully given in the paper quoted above in the *Journal of Physiology*, vol. xxiii.

*The Reflex Spasm.*—We may now pass to *reflex action*, in which, since the motor apparatus of the cord has to be first excited through a sensory nerve, the time which elapses before a response is evoked is necessarily longer than in the cases we have been so far considering. The


FIG. 4.—The photographic curve of tetanus. The radial indicates the beginning of the period of excitation.

response, if the motor cells of the cord have been rendered extra sensitive by a minute dose of strychnine, is a prolonged contraction [tracing of mechanical effect shown] the graphic of which is often indistinguishable from that of complete tetanus. When the electrical concomitants of such a spasm are recorded photographically (Fig. 6), it is seen that the curve resembles rather that of complete tetanus interrupted at regular intervals, than that of a series of responses to single instantaneous stimuli following each other at intervals of a tenth of a second or more. And by analysing the curve we learn that the difference which in the first instance comes into existence between the contacts, disappears and reappears rhythmically, and finally ceases. A single stimulus to the motor cells of the cord has therefore produced a series of short prolonged responses in the muscle, of which the rhythm is *central*, not muscular. The motor cell pours its influence on the muscle at regular intervals, but its effect each time is that of a continuous action.

The property which a muscle has of, under ordinary experimental conditions, relaxing as soon as the exciting


FIG. 5.—Tetanus of short duration, followed by another after an interval during which the muscle was not excited.

cause ceases, appears at first to indicate discontinuity of voluntary action. We have, however, a means of removing this property without materially impairing the functional capacity of the muscle. This means is furnished by the alkaloid *veratrine*. So long as this is used in sufficiently small quantity ($\frac{1}{10000}$ mgr. to a sartorius), its effect consists chiefly in the annulling of the unknown inhibitory mechanism, by virtue of which a muscle, after having responded to an instantaneous stimulus, at once returns to its previous state. Under the influence of veratrine, when once started to work it is compelled to go on. [It was shown by graphic records that a muscle so treated can do as much work in response to a single instantaneous stimulus, whether in lifting heavy loads or in producing tension, as a normal muscle subjected to a series of instantaneous stimuli.] The electrical phenomena evoked by a single stimulus in a veratrinised muscle likewise show that the effect is absolutely continuous; there is no trace of unevenness or undulation in the photographic curve (Fig. 7), the contour of which resembles the general contour of artificial tetanus, *i.e.* a sudden difference of potential comes into existence at the moment of excitation, but, notwithstanding that it is evoked by an instantaneous stimulus, it persists as if it were the response to a continuous one.


FIG. 6.—Reflex response of sartorius to instantaneous excitation in strychnised preparation.

To complete the subject, it is necessary to describe the electrical phenomena which accompany the action of the heart. In all that has preceded, a parallel-fibred muscle has been employed in which the excitatory wave is propagated along the fibres in two opposite directions only. In the heart the fibres are short, and run in all directions. The wave of excitation may originate anywhere, and may spread in any direction. We employ the ventricle of the heart of the frog, having first arrested its rhythmical beat by a ligature between sinus and auricle. We can then evoke a contraction by an instantaneous excitation at any part of its surface, and thus imitate the first fundamental experiment in muscle. At the excited point the surface becomes instantly negative to all other parts, and the state of relative negativity spreads radially just as in muscle it was propagated longitudinally, the electrical effect appearing to precede the mechanical. Moreover, the duration of the process is ten times as long, and the rate of propagation ten times as slow. But in other respects the two processes in cardiac and skeletal muscle

are so analogous, that if the distance of the contacts, the duration of the change at the seat of excitation (monophasic variation), and the rate of propagation are known, it is easy to forecast the curve of the diphasic variation.

By a similar method to that employed in the study of muscle, the effect at the distal contact can be partially or entirely cancelled. All that is necessary is to destroy by heat the surface under the distal electrode. The result of this operation is that, as in muscle, the devitalised area becomes, while unexcited, negative to all uninjured parts, and that if the surface is excited in the neighbourhood of the uninjured contact, the photographic curve assumes characters which correspond with those of the monophasic curve of muscle, with this noteworthy difference that its duration is that of the ventricular beat.


FIG. 7.—Response of veratrinised muscle to instantaneous stimulation.

This can be best understood from the photographic curves reproduced in Fig. 8, with reference to which it is to be noted that the rate of movement of the plate on which the movement of the mercury column is projected is *ten times* as slow as the slowest rate of movement used in observations of muscle. Had the excursion been projected on a plate moving at the same rate, the first half of the curve would have had a contour similar to the veratrine curve. It expresses a sudden coming into existence of a difference of potential between the two contacts which may be maintained (in the heart) for more than two seconds.

In the second curve of Fig. 8 the curve begins as in the first, but the effect on the electrometer of the change which is taking place at the proximal electrode is immediately afterwards counteracted and balanced by the similar change at the distal contact, and is followed by a period of indifference, the end of which is marked by a descent of the column. This (as was explained by the lecturer many years ago) means that the effect at the distal electrode over-lasts that which occurs at the proximal.

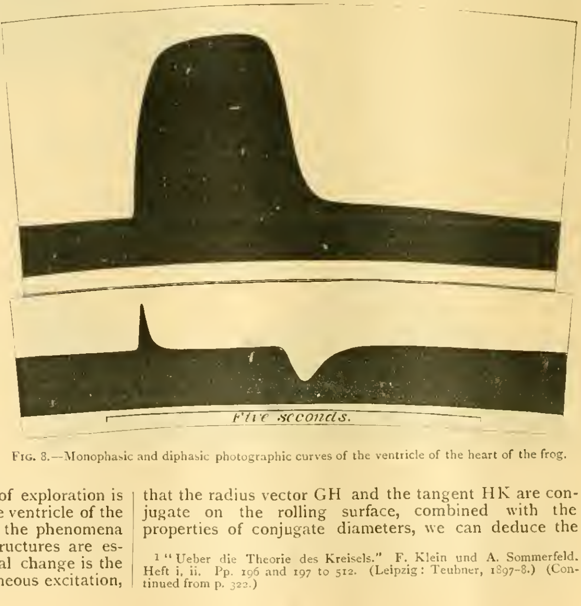



FIG. 8.—Monophasic and diphasic photographic curves of the ventricle of the heart of the frog.

The lecture concluded with a comparison of the electromotive properties of the leaf of the fly-trap with those of muscle. If the same method of exploration is applied to the surface of the leaf as to the ventricle of the heart of the frog, it is easy to show that the phenomena observed after excitation in the two structures are essentially analogous. In both an electrical change is the immediate result of a localised instantaneous excitation, and this change spreads from the excited spot to parts at a distance at a rate which varies with temperature. The interval of time between the culmination of the electrical response and that of the change of form is much more obvious in the leaf than in the heart, because the mechanism by which the latter manifests itself works very slowly, as compared even with cardiac muscular fibres. This contrast, however, affords no ground for doubting that the two processes are, as regards their intimate nature, analogous.

## *MATHEMATICS OF THE SPINNING-TOP.*[1]

### II.

IT is instructive at this stage to go behind the various relations given by Darboux and Routh, connecting A, B, C, D, and $\delta$, and the accented letters, and to examine their inner geometrical significance; various interesting theorems of Geometrical Conic Sections will be required, which will show the practical utility of the study of this elegant subject, as presented in Taylor's "Geometry of Conics."

In the first place we can connect up the notation of Darboux and Routh by taking

$$(28)\quad \frac{a,\ b,\ c,\ h}{m} = \frac{\text{HV, HT, HP, HQ}}{\text{OD}} = \left(\frac{\text{D}}{\text{A}},\ \frac{\text{D}}{\text{B}},\ \frac{\text{D}}{\text{C}},\ 1\right)\frac{\text{HQ}}{\text{OD}},$$

Darboux's $a$, $b$, $c$, $h$ being of the same dimensions as $m$, an angular velocity estimated in radians/second.

From the fundamental property of the herpolhode as the trace of the points of contact of a quadric surface, rolling about its centre O on a fixed plane GH, namely, that the radius vector GH and the tangent HK are conjugate on the rolling surface, combined with the properties of conjugate diameters, we can deduce the

[1] "Ueber die Theorie des Kreisels." F. Klein und A. Sommerfeld. Heft i, ii. Pp. 196 and 197 to 512. (Leipzig: Teubner, 1897-8.) (Continued from p. 322.)

analytical theorems of the curve. Thus, if OE and OF are the conjugate diameters parallel to the tangent HK and the vector GH, and if OK is the perpendicular on HK, then, with Darboux's notation,

$$a+b+c=\mathrm{P},\ bc+ca+ab=\mathrm{Q},\ abc=\mathrm{R},$$

and putting

$$\frac{\mathrm{OG}^2}{\mathrm{OD}^2}=\frac{h}{m},$$

$$(29)\qquad \frac{\mathrm{OE}^2+\mathrm{OF}^2+\mathrm{OH}^2}{\mathrm{OD}^2}=\frac{\mathrm{P}}{m},$$

$$(30)\qquad \frac{\mathrm{OE}^2 . \mathrm{OF}^2 \sin^2 \mathrm{EOF}+\mathrm{OK}^2 . \mathrm{OE}^2+\mathrm{OF}^2 \quad \mathrm{OG}^2}{\mathrm{OD}^4}=\frac{\mathrm{Q}}{m^2},$$

$$(31)\qquad \frac{\mathrm{OG}^2 . \mathrm{OE}^2 . \mathrm{OF}^2 \sin^2 \mathrm{EOF}}{\mathrm{OD}^6}=\frac{\mathrm{R}}{m^3}.$$

The elimination of $\mathrm{OE}^2$, $\mathrm{OF}^2$, and $\sin^2 \mathrm{EOF}$ between these equations gives the relation connecting $\mathrm{OH}^2$ and $\mathrm{OK}^2$ in the herpolhode; it is linear in $\mathrm{OK}^2$ and quadratic in $\mathrm{OH}^2$. The geodetic radius of curvature of the polhode on the polhode cone is readily found by a differentiation by exactly the same formula as the *rdr dp* formula of a plane curve; and the radius of curvature of the herpolhode in the plane of G is the projection of this geodetic radius of curvature.

At a point of inflexion on the herpolhode this geodetic radius of curvature is infinite, and now the polhode is a bit of a geodesic on the polhode cone; this shows that the osculating plane of the polhode is now perpendicular to OK.

But to find whether the herpolhode can have points of inflexion, we merely require to find where the value of OK is stationary, and this is found by solving the quadratic in $\mathrm{OH}^2$, and examining its discriminant; in this way we shall find that the discriminant vanishes, and OK is at a turning point, when

$$(32)\qquad m\frac{\mathrm{GK}^2}{\mathrm{OD}^2}=0,\ \text{ or }\ \frac{4(a-h)(b-h)(c-h)\mathrm{R}}{\Omega^2 h},$$

where, in Darboux's notation,

$$\Omega^2=\mathrm{Q}^2-4\mathrm{R}(\mathrm{P}-h).$$

The value GK = 0 is excluded when the rolling surface is an ellipsoid; it will be found that the other value makes

$$m\frac{\mathrm{OF}^2}{\mathrm{OD}^2}=\frac{\mathrm{Q}}{2h},$$

$$m^2\frac{\mathrm{OF}^2 . \mathrm{OG}^2}{\mathrm{OD}^4}=\tfrac{1}{2}\mathrm{Q};$$

and the maximum value of this being $ab$, it follows that

$$ab-\tfrac{1}{2}\mathrm{Q}=\tfrac{1}{2}\mathrm{R}\left(\frac{1}{c}-\frac{1}{a}-\frac{1}{b}\right)=\frac{1}{2}m^2\frac{\mathrm{HQ}^2}{\mathrm{OD}^2}\frac{\mathrm{D}^2}{\mathrm{ABC}}(\mathrm{C}-\mathrm{A}-\mathrm{B})$$

is positive, so that the rolling quadric cannot be the momental ellipsoid of real positive matter for points of inflexion to exist, in accordance with the theorems of Hess and de Sparre.

Fig. 1 has been drawn with the idea at first of giving the graphical representation of the numerical case discussed in VI. § 6; so that

$$f=\frac{a-b}{\omega'}=-0{\cdot}0068,\quad f'=\frac{a+b}{\omega'}=1{\cdot}421$$

(these numbers appear to show that $s$ and $s'$ on p. 481 must be interchanged).

But as these numbers bring the point P inconveniently near to A, fresh dimensions are chosen; we can take a scale such that OA = 10 cm., OB = 5, so that $\kappa$ is reduced from 0·521 to 0·5; and the points P and P′ were so placed as to make $\theta_3 = 45°$, $\theta_2 = 30°$; and now, by measurement, OD = 17·73 cm.,

| | |
|---|---|
| HQ = 16·4 cm. | HQ′ = 8·9 cm. |
| HT = 5·4 cm. | HT′ = 21·6 cm. |
| HV = 15·0 cm. | HV′ = 8·3 cm. |
| HP = 6·2 cm. | HP′ = 10·4 cm. |

The angle AOQ or $\omega = 33°$ by measurement, so that from Legendre's Table IX., to the co-modular angle 60°,

$$\mathrm{F}\omega=0{\cdot}6009,\quad \mathrm{K}'=2{\cdot}1565,$$
$$\mathrm{E}\omega=0{\cdot}5528,\quad \mathrm{E}'=1{\cdot}2111;$$

and thence

$$f=-0{\cdot}2787,$$

and

$$\mathrm{QL}=2{\cdot}153\ \text{cm}.$$

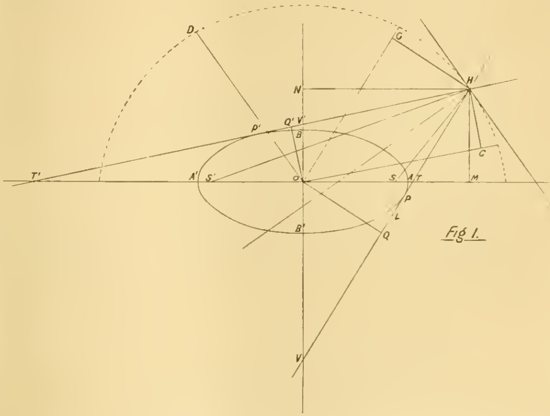



Fig. 1.

Thence the apsidal angle, as a fraction of a right angle, is given by

$$(33)\qquad \frac{\Psi}{\frac{1}{2}\pi}=\frac{\mathrm{HL}}{\mathrm{OA}}\frac{\mathrm{K}}{\frac{1}{2}\pi}+f=1{\cdot}245.$$

As $\theta$ diminishes from $\theta_3$ to $\theta_2$, the deformable hyperboloid opens out from the plane of the focal ellipse and flattens again in the plane of the focal hyperbola. As a typical intermediate position choose that of half-time; with our dimensions this will make

$$\sin^2\phi=\frac{1}{1+\kappa'}=0{\cdot}5359,$$

$$\cos\theta=0{\cdot}792,\ \theta=37°\ 37'.$$

Project the figure on to the plane of the generating lines HQ, HQ′, which are now drawn inclined at 37° 37′, and place the points Q, T, V, P, &c., on these lines as before; the confocal quadrics project into confocal conics.

The lines TT′, VV′, PP′ form a triangle XYZ, the sides of which are the traces of the principal planes: $\Omega$, the orthocentre of this triangle, is the projection of the origin O.

We must be content with the mere statement of the following geometrical theorems, required for throwing light upon the analytical theorems of this dynamical problem, with a view of obtaining a clear image of the motion in accordance with Poinsot's ideas; the demonstrations will be found in Salmon's "Solid Geometry,"

or better still, in Mannheim's "Géométrie Cinématique," which has been found valuable in carrying on the Poinsot traditions of dynamical presentation.

Join HΩ, cutting the sides of the triangle XYZ in $\alpha, \beta, \gamma$; describe the circle round XYZ, and let XΩ, YΩ, ZΩ cut this circle in $d, e, f$; then $\alpha d$, $\beta e$, $\gamma f$ intersect the circle in one point F. F is the focus, and HΩ the directrix of the parabola, which is the envelop of the normals of the confocals (Salmon, "Solid Geometry," § 177); this parabola touches the sides of the triangle XYZ; the tangents to the parabola from H are tangents to the projections on the plane of the confocals through H, while the tangents to the parabola from Ω are the axes of these plane confocals; also HΩ and HF are equally inclined to HQ and HQ'.

If H$c$, H$c'$ are the tangents to the parabola from H, the points of contact $c$ and $c'$ are the centres of curvature of the plane confocals through H; while C and C', the centres of curvature of the normal sections of the confocal surfaces through H made by planes through the line of curvature traced out H, are such that

$$\mathrm{HC} = \mathrm{H}c \cos^2 \tfrac{1}{2}\theta, \quad \mathrm{HC}' = \mathrm{H}c' \sin^2 \tfrac{1}{2}\theta,$$

and thus the point C and C' are easily constructed geometrically.

The line CC (a tangent to the parabola) is Mannheim's *axis of curvature*, and the plane through H perpendicular to it is the osculating plane of the polhode. Thus in the degenerate case of Fig. 1, when H lies in the plane of the focal ellipse, PP' is the axis of curvature of the polhode, while Z and Ω coincide with O.

The various relations in the conjugate Poinsot movements, investigated by Darboux and Routh, and given in VI. § 8, can now receive a geometrical interpretation.

Thus the relation (2), p. 476, written in the form

$$(34) \qquad \frac{\mathrm{B}}{\mathrm{A}} + \frac{\mathrm{B}'}{\mathrm{A}'} = \frac{\mathrm{C}}{\mathrm{A}} + \frac{\mathrm{C}'}{\mathrm{A}'}, \text{ \&c.},$$

is the equivalent of

$$(35) \qquad \frac{\mathrm{HV}}{\mathrm{HT}} + \frac{\mathrm{HV}'}{\mathrm{HT}'} = \frac{\mathrm{HV}}{\mathrm{HP}} + \frac{\mathrm{HV}'}{\mathrm{HP}'}, \text{ \&c.};$$

expressing the fact that, if PP' cuts OA in X in Fig. 1, then MX is the harmonic mean of HT, HT' and of H$m$, H$m'$, where $m$, $m'$ are the feet of the ordinates from P, P' on OA.

Again, if XΩ meets YZ in D, then OD and OV are conjugate diameters in the principal plane OYZ of the rolling quadric

$$(36) \qquad \frac{x^2}{\mathrm{HV}} + \frac{y^2}{\mathrm{HT}} + \frac{z^2}{\mathrm{HP}} = \mathrm{HQ},$$

and therefore

$$\frac{\mathrm{HP}}{\mathrm{HT}} = \tan \mathrm{YOD} \tan \mathrm{YOV} = \frac{\mathrm{VY}}{\mathrm{VZ}};$$

similarly

$$\frac{\mathrm{HV}}{\mathrm{HP}} = \frac{\mathrm{TZ}}{\mathrm{TX}}, \quad \frac{\mathrm{HT}}{\mathrm{HV}} = \frac{\mathrm{PX}}{\mathrm{PY}};$$

so that, drawing X$x$ parallel to YZ to meet HQ and HQ' in $x$ and $x'$,

$$\frac{\mathrm{HV}}{\mathrm{HT}} = \frac{\mathrm{PV}}{\mathrm{PX}} = \frac{\mathrm{PV}}{\mathrm{P}x}, \quad \frac{\mathrm{HV}}{\mathrm{VT}} = \frac{\mathrm{PV}}{\mathrm{V}x}.$$

$$(37) \qquad \frac{\mathrm{VP.VT}}{\mathrm{HV}^2} = \frac{\mathrm{V}x}{\mathrm{HV}} = \frac{\mathrm{V}'x'}{\mathrm{HV}'} = \frac{\mathrm{V'P'.V'T'}}{\mathrm{HV}'^2}$$

the geometrical equivalent of the relation

$$(38) \qquad \left(1 - \frac{\mathrm{A}}{\mathrm{B}}\right)\left(1 - \frac{\mathrm{A}}{\mathrm{C}}\right) = \left(1 - \frac{\mathrm{A}'}{\mathrm{B}'}\right)\left(1 - \frac{\mathrm{A}'}{\mathrm{C}'}\right).$$

Similarly for the other relations, which we have not space to develop.

The A and C employed here require to be carefully distinguished from the values referring to the top itself, which ought to be differentiated by a suffix.

The constancy of the perpendicular from the centre on the tangent plane of the rolling quadric along the polhode is expressed by

$$(39) \qquad \frac{x^2}{\mathrm{HV}^2} + \frac{y^2}{\mathrm{HT}^2} + \frac{z^2}{\mathrm{HP}^2} = 1,$$

and

$$\frac{x}{\mathrm{HV}}, \quad \frac{y}{\mathrm{HT}}, \quad \frac{z}{\mathrm{HP}}$$

are obviously the cosines of the angles which the line HQ makes with the coordinate axes.

The Darboux-Kœnig's arrangements by which the polhode, herpolhode, and associated top motion are produced mechanically by articulated movements, are worth mention and study in elucidating the various theorems.

When the parameters $a$ and $b$ (p. 263) are aliquot parts of the period $\omega'$, the multiplicative elliptic functions $\alpha, \beta, \gamma, \delta$ become algebraical functions of $u$, qualified by exponential functions of the time. Take the simplest case, where $a = \frac{1}{2}\omega'$, $b = \frac{1}{2}\omega'$, equivalent to placing P at A and P' at B in Fig. 1, then we shall have

$$e = 0, \quad e' = \kappa, \quad e'' = \frac{1}{\kappa};$$

$$\alpha = \frac{1}{\sqrt{2}} e^{lti}\left[\sqrt{(e'' - u \,.\, e' - u)} + i\frac{1+\kappa}{\sqrt{\kappa}}\sqrt{(u - e)}\right]^{\frac{1}{2}},$$

$$\beta = \frac{1}{\sqrt{2}} e^{l'ti}\left[\sqrt{(e'' - u \,.\, e' - u)} - i\frac{1-\kappa}{\sqrt{\kappa}}\sqrt{(u - e)}\right]^{\frac{1}{2}}, \text{ \&c.},$$

with

$$l = \frac{1+\kappa}{4\sqrt{2\kappa}} m + \tfrac{1}{2}\left(\frac{1}{\mathrm{C}} - \frac{1}{\mathrm{A}}\right)\mathrm{N},$$

$$l' = \frac{1-\kappa}{4\sqrt{2\kappa}} m - \tfrac{1}{2}\left(\frac{1}{\mathrm{C}} - \frac{1}{\mathrm{A}}\right)\mathrm{N},$$

$$\tfrac{1}{2} i \sin \theta e^{\psi i} = \alpha\beta = \tfrac{1}{2} e^{(l+l')ti}\left[\sqrt{(1 - \kappa u)} + i\sqrt{(u \,.\, \kappa - u)}\right].$$

In the next case, where

$$a = \tfrac{2}{3}\omega', \quad b = \tfrac{1}{3}\omega',$$

it is found that we can put

$$e = -1 + c, \quad e' = -\frac{1 - 3c + c^2}{(1-c)^2}, \quad e'' = \frac{1-c}{c};$$

$$\alpha = \frac{1}{\sqrt{2}} e^{lti}\left[\frac{(1 - c + c^2)u + (1-c)^2}{(1-c)\sqrt{c}} + i\sqrt{\mathrm{V}}\right]^{\frac{1}{3}}$$

$$\beta = \frac{1}{\sqrt{2}} e^{l'ti}\left[\frac{(1-2c)(2-c)}{(1-c)\sqrt{c}}\sqrt{(e'' - u \,.\, u - e)} + i\left\{u - 2\frac{(1-c)^2}{c}\right\}\sqrt{(e' - u)}\right]^{\frac{1}{3}}, \text{ \&c.}$$

with

$$l = \tfrac{1}{3}\frac{1 - c + c^2}{(1-c)\sqrt{2c}} m + \tfrac{1}{2}\left(\frac{1}{\mathrm{C}} - \frac{1}{\mathrm{A}}\right)\mathrm{N}$$

$$l' = -\tfrac{1}{3}\frac{(2-c)(1-2c)}{(1-c)\sqrt{2c}} m - \tfrac{1}{2}\left(\frac{1}{\mathrm{C}} - \frac{1}{\mathrm{A}}\right)\mathrm{N}.$$

The general form of this solution can now be inferred, but it is evident that the algebraical complexity mounts up very rapidly; with

$$a = \frac{2r\omega'}{n}, \quad b = \frac{r\omega'}{n},$$

$$\alpha = \frac{1}{\sqrt{2}} e^{lti}\left[\mathrm{A}_1 + i\mathrm{A}_2\sqrt{\mathrm{V}}\right]^{\frac{1}{n}},$$

$$\beta = \frac{1}{\sqrt{2}} e^{l'ti}\left[\mathrm{B}_1\sqrt{(e'' - u \,.\, u - e)} + i\mathrm{B}_2\sqrt{(e' - u)}\right]^{\frac{1}{n}},$$

where the A's and B's are rational polynominals of $u$.

Thus for $n = 5$, we can take

$$e = -\frac{2c}{\sqrt{\mathrm{C}} + 1}, \quad e' = \frac{c^3 - 3c^2 - c - 1}{4c}, \quad e'' = \frac{2c}{\sqrt{\mathrm{C}} - 1},$$

where

$$\mathrm{C} = c^3 + c^2 - c;$$

and

$$\mathrm{A}_1 = \mathrm{P}u^2 + \mathrm{P}_1 u + \mathrm{P}_2, \quad \mathrm{P} = \frac{c^3 - c^2 + 7c - 3}{2c^{\frac{1}{2}}(c+1)(c-1)^{\frac{1}{2}}},$$

$$P_1 = \frac{5c^5 - 11c^4 + 26c^3 - 10c^2 + c - 1}{2c^{\frac{3}{2}}(c+1)^3(c-1)^{\frac{1}{2}}}, \quad P_2 = \frac{c^4 - 10c^3 + 2c^2 - 2c + 1}{c^{\frac{1}{2}}(c+1)^3(c-1)^{\frac{1}{2}}};$$

$$A_2 = u + \frac{5c^2 - 2c + 1}{c(c+1)^2}, \quad l = \frac{P}{5\sqrt{2}} + \tfrac{1}{2}\left(\frac{1}{C} - \frac{1}{A}\right)N;$$

$$B_1 = Qu + Q_1,$$

where

$$Q = \frac{(c+3)(c^2 - 4c - 1)}{2c^{\frac{1}{2}}(c+1)(c-1)^{\frac{1}{2}}}, \quad l' = \frac{Q}{5\sqrt{2}} - \tfrac{1}{2}\left(\frac{1}{C} - \frac{1}{A}\right)N,$$

$$Q_1 = -\frac{(c^2 - 4c - 1)(5c^2 + 2c + 1)}{2c^{\frac{3}{2}}(c+1)(c-1)^{\frac{3}{2}}}.$$

$$B_2 = u^2 - \frac{5c^3 + 19c^2 + 7c + 1}{c(c+1)^2(c-1)}u + \frac{-2c^3 + 22c^2 + 10c + 2}{(c+1)^2(c-1)^2}.$$

The same functions $\alpha$, $\beta$, $\gamma$, $\delta$, and their special algebraical forms are suitable for Kirchoff's case of the motion of a solid in infinite liquid, but now V is a quartic function of $u$, requiring resolution into factors.

In the more general case invented by Clebsch, and developed in Halphen's "Fonctions elliptiques," t. II., the component rotation about OZ is no longer constant, and the solution is more complicated, introducing multiplicative elliptic functions to a parameter corresponding to the infinite value of $u$.

If the motion of the axis of the top is alone required, we take $\Lambda = \infty$, and investigate the function $\lambda = \alpha\gamma$; this is a multiplicative elliptic function, with an effective parameter $a-b$, which can be made algebraical when $a-b$ is made an aliquot part of $\omega'$, irrespective of the separate terms $a$ and $b$. By a further restriction, the exponential function of the time can be made to disappear by making $l + l' = 0$, and then H is at L in Fig. 1; it was in this way that the analysis was prepared of the algebraical cases, represented stereoscopically by Mr. T. I. Dewar, referred to on p. 199.

The authors say they have refrained from utilising these stereoscopic diagrams, because they would not like to assume in the reader the possession of a stereoscope. But our eyes should be drilled into control to pick up the solid appearance without any apparatus; a little quiet practice will suffice. Treatises on Solid Geometry of the future should be profusely illustrated with stereoscopic figures, which the student should see solid at will; and wall diagrams or lantern projections should also be drawn stereoscopically, and the solid effect obtained in the audience by crossing the two lines of sight.

Mr. T. I. Dewar's untimely death, at San Remo last May, has deprived us of any further diagrams from his skill, but the example he set will we trust be followed out completely in mathematical diagrammatic instruction.

The unsymmetrical top, discussed in V. § 9, leads into such great analytical complication, that only a few special degenerate cases have so far received any adequate attention; the next century will have its work cut out for the mathematical treatment of this problem and also of the dynamics of the bicycle. The symmetrical top of the boy, with the point free to wander over a smooth or rough horizontal plane, leads to similar analytical difficulties, and should be discussed in the same place.

On the other hand, the many attempts at a popular explanation of the motion of the top, restricted principally to the case of regular precession, are described in V. § 3. Prof. Perry's interesting little book on "Spinning Tops" comes in for praise, and the authors cite with pleasure the comparison of the top to a wilful beast (*eigensinniger Thier*), always ready to move in some other direction to that in which it is pushed; insomuch that the Irishman can persuade his pig to accompany him on the road only by pretending that his way lies in the opposite direction; and so Bessemer's invention to steady the motion of a cabin mounted on gimbals, by means of the controlling influence of gyrostats, was a failure.

If the authors are in search of other practical elementary illustrations, they should take the modern centrifugal machine, and examine the practical devices, as in the Weston machine, for controlling the nutations; these devices discovered experimentally without any assistance from theory will serve to elucidate the abstract formulas with advantage.

A third part of this book is still to appear, and we await it with great interest; the work when complete will form an indispensable book of reference for all who wish to make themselves thoroughly acquainted with this complicated problem in Dynamics.

A. G. GREENHILL.

## *NOTES.*

AT Osborne, on Wednesday, August 2, the Queen conferred the honour of knighthood upon Sir William Henry Preece and Sir Michael Foster, Knight Commanders of the Order of the Bath, and invested them with the riband and badge of the Civil Division of the Second Class of the Order, and affixed the star to their left breasts.

THE Hanbury Gold Medal of the Pharmaceutical Society of Great Britain has been awarded to Prof. Albert Ladenburg, of Breslau, for his work on alkaloids and their derivatives.

MR. J. S. BUDGETT, of Trinity College, Cambridge, who accompanied Mr. Graham Kerr on his expedition in search of *Lepidosiren*, has been successful in obtaining eggs and larvæ of the Crossopterygian Ganoid *Polypterus*. From a short account of his investigations, illustrated by sketches, which Mr. Budgett has sent to this country, it appears that the larva is very minute, and possesses a "cement organ" on the dorsal surface of the head. Mr. Budgett is now on the journey home, and the full account of his work will be looked forward to with much interest.

ON a preceding page we have referred to some of the work performed by the Royal Gardens, Kew. Coincidently we have received the number for July 21 of our American contemporary *Science*, which contains an elaborate article by Prof. Underwood, headed "The Royal Botanic Gardens at Kew," in which the features of the garden and its position as a scientific institution —"its beautiful lawns, its delightful shade, its historic associations, its immense collections of cultivated plants, and its wonderful activity in the direction of botanical research"—are described and discussed with critical appreciation *apropos* the recent establishment of the Botanic Garden of New York and its capability to become "even more influential in democratic America than Kew has become throughout the length and breadth of the Queen's dominions." It is gratifying to have this acknowledgment of the work of Kew; and the tribute paid to the versatility and ability of Sir William Thiselton-Dyer in promoting its development and widening its influence will be everywhere endorsed. There are some blots on the escutcheon in the eyes of Prof. Underwood, but we imagine there are many who will not see with him in all the instances he mentions. The crowding of the museum collections he notes is an apparent blemish, and one we may hope to see removed by the provision of increased room for the exhibition of the specimens. A somewhat jealous comparison of Kew and Berlin as centres of botanical work is a jarring note in the article; and Prof. Underwood allows, we fear, German bias to weigh with him in making it, for instance, when he writes, "the principles of plant distribution are not so thoroughly grasped at Kew as they have been brought out at the German Botanical Garden through the skill of Prof. Engler and his associates." Yet Kew is the home of Sir Joseph Hooker!

FOR several years the need of greater facilities for the publication of mathematical investigations has been strongly felt by the members of the American Mathematical Society. This Society has maintained during the past eight years an historical and critical review, known as the *Bulletin* of the American Mathematical Society, and throughout the whole of this period there has been a constantly growing demand for the publication in the pages of that journal of articles not properly falling within its scope. The co-operation of several American colleges and universities was therefore recently invited in a plan whereby such articles may be afforded suitable means of publication. The necessary co-operation has now been secured, and the publication of a quarterly number of the *Transactions* of the American Mathematical Society has been definitely undertaken to begin January 1, 1900. The *Transactions* will be devoted primarily to research in pure and applied mathematics. The editors will welcome all papers containing investigations of sufficient mathematical interest and value. Such papers, in many cases, will be necessarily of considerable length; but the editors will be very glad to receive, also, short contributions which are of such a character as to fall within the scope of the *Transactions*. Papers from mathematicians not belonging to the Society will be welcomed; such papers, if accepted for publication, will be presented to the Society by the editors. Manuscripts intended for publication in the *Transactions* should be addressed either to Prof. E. H. Moore, University of Chicago, Chicago, Ill., or to Prof. E. W. Brown, Haverford College, Haverford, Pa., or to Prof. T. S. Fiske, Columbia University, New York, N.Y.

BY the will of the late Dr. Jules Maringer, the Pasteur Institute at Paris is bequeathed the sum of one hundred thousand francs.

THE death is announced at Olten, Switzerland, of M. N. Rieggenbach, Correspondant of the Paris Academy of Sciences, in the Section of Mechanics.

*Science* announces the death of Mrs. Elizabeth Thompson, of Stamford, Conn., who made many gifts for benevolent and scientific purposes. She contributed towards the telescope for Vassar College, was one of three "patrons" of the American Association for the Advancement of Science, and endowed the Elizabeth Thompson Science Fund, the income of which is now being so advantageously used for the promotion of scientific research.

A REUTER despatch from St. Petersburg, dated August 2, says:—"News has been received here that the Russian members of the Russo-Swedish Scientific Expedition to Spitsbergen have arrived safely at Horn Sound, where they will winter. Later on they will proceed by land to the western side of the Stor Fiord, where they will engage in geodetic work. Some of the members will not remain over the winter, returning to St. Petersburg in October, but the others will stay in Spitsbergen until the autumn of next year. The Russian members of the expedition have not yet met with their Swedish colleagues; but Prof. Baklund has gone to meet them on board an ice-breaker."

REFERRING to the progress of vaccination, Mr. Chaplin said, in the House of Commons on Thursday last, that the returns which he had obtained showed that the total number of certificates of successful primary vaccination received by the vaccination officers during the first six months of the present year was 353,992 as against 277,821 in the first six months of 1898; that is to say, there has been an increase of upwards of 76,000 primary vaccinations or of more than 27 per cent. in the first six months of the present year as compared with the corresponding period of 1898. These results have been obtained in the first six months of the Act, notwithstanding the difficulty of giving effect to an entire change of method throughout the country from stational to domiciliary vaccination; and also in spite of the fact that in numerous cases there was very considerable delay in the fixing of fees and the appointment of officers.

FROM a note in the *Times* we learn that the section of the famous mpundu tree at Chitambo's, which marked the place where Dr. Livingstone died, has been successfully removed by Mr. Codrington, the Deputy-Administrator of Northern Rhodesia, and will be sent to England for preservation. It will be remembered that two or three years ago Mr. Poulett Weatherley, while exploring in the neighbourhood of Lake Bangweolo, visited Chitambo's and reported that the mpundu tree was in an advanced stage of decay and would probably disappear altogether in a very short time. After careful consideration, the Royal Geographical Society decided that the best course to pursue would be to cut out the section of the tree which bears the inscription and have it sent over to London for preservation at the rooms of the Society. To mark the place where the tree stood, a large cairn has been erected with a staff made of two telegraph poles in the centre, held in place by stays of telegraph wire. This temporary memorial will serve the purpose of preserving the identity of Dr. Livingstone's deathplace until such time as a more permanent memorial is erected.

THE sixth international otological congress was opened on Tuesday at the Examination Hall, Victoria Embankment. Prof. U. Pritchard, the president-elect, was in the chair, and about three hundred aural surgeons from many parts of the world were present. In his presidential address, Prof. Pritchard traced the birth and growth of otological science. Although an ancient Egyptian papyrus had been found on which was written a monograph on deafness and ear diseases, otology, except perhaps with regard to its anatomy and physiology, did not make itself of great importance until the second half of the present century. Between 1840 and 1860 this branch of medical science was vigorously taken up by Sir William Wilde and Toynbee. Since then the means of diagnosis have been considerably improved, while in treatment there has been immense strides, due to the adoption of antiseptic surgery. At the commencement of the present century the ear was regarded almost as a *terra incognita*, scarcely worth consideration except as the seat of one affection only—that which was generally known as "a deafness"—now, at its close, this organ is fully-explored ground, and has been proved well worth the exploration. Otology has been raised from the rank of pseudo-quackery to an honourable position in scientific surgery, and its importance and bearing upon the body as a whole is now fully recognised.

THE results of experiments on the ignition of fire-damp and coal-dust by means of electricity were given in a paper by Herr Heise and Dr. Theim, recently read before the Institution of Mining Engineers. The object of the experiments was to determine to what extent electrically driven machinery is dangerous in fiery or dusty mines. In brief, the sum of the results obtained show that in general the amount of electrical energy which is capable in certain circumstances of igniting fire-damp need only be extremely small. This amount cannot be definitely fixed, however, as it depends not only on the quantity of energy but on the mode of its application and other attendant circumstances. It is only in the case of a current the conditions of which are exactly known that quantitative statements can be made as to the limits of safety for certain classes of transformation of energy. In any case, all visible sparks may be looked upon as dangerous. Experiment alone can decide whether certain classes of sparks

may be devoid of danger. Explosions of coal-dust alone appear to be impossible of production by electricity, unless indeed specially dangerous classes of coal-dust behave differently from those tried.

A COPY of a paper by Dr. J. S. Haldane, F.R.S., and Mr. F. G. Meachem, containing observations on the relation of underground temperature and spontaneous fires in the coal to oxidation and to the causes which favour it, has been received from the Institution of Mining Engineers. The conclusions to which the results of the investigations have led the authors are as follows: (1) A very large amount of heat, sufficient often (if not otherwise absorbed) to heat the air-current to boiling point, is always being formed in a mine, and this heat is almost entirely produced by oxidation of material in the mine. (2) The heat formed greatly exceeds in amount, as a rule, the heat withdrawn by the air-current, so that the temperature of the mine, or of some parts of it, is above that of the strata. (3) The disappearance of oxygen and liberation of heat in the mine are probably due, largely at least, to oxidation of iron pyrites; and the liberation of carbonic acid in the mine is probably due to the action on carbonates of the sulphuric acid thus formed. (4) Coal, when exposed to air, absorbs oxygen, and may also give off carbonic acid and fire-damp, and a very small amount of carbonic oxide. (5) The rate of absorption of oxygen by coal varies directly with the proportion of oxygen present in the air; and as the temperature of the coal increases in arithmetical progression the rate of oxygen-absorption increases in geometrical progression, the ratio of increase (for the coal experimented upon) being about 1/10 for every 4° Fahr. of increase in temperature.

THE engineering papers publish particulars of the series of trials made at Liverpool last week of self-propelled vehicles suitable for heavy traffic. The chief object of the trials was to encourage the development of types of heavy motor wagons suitable for trade and agricultural requirements. The trial runs were made from Liverpool, over distances of from thirty to forty miles, on two successive days. All vehicles were required to traverse the prescribed routes without alternative, and to perform other manœuvres. The distance between any two of the depôts provided for the supply of water did not exceed twelve miles. Steam was used as the motive power in the six vehicles entered for competition this year. Oil was used for fuel in three, coal in two, and coke in one. Electricity and oil motors were unrepresented in the competition. The following awards were made by the judges:—In Class B, for vehicles having a minimum load, 2 tons; maximum tare, 2 tons; minimum level platform area, 50 square feet, a gold medal to the Steam Carriage and Wagon Company (Thorneycroft), Chiswick, and silver medals to Bayley's, Limited, and the Lancashire Steam Motor Company. In Class D, for vehicles with a minimum load of 6½ tons; maximum tare, 4 tons; minimum level platform area, 110 square feet, the gold medal was awarded to the Steam Carriage and Wagon Company (Thorneycroft).

A COMMITTEE of the British Association was appointed in 1896 to take any possible measures to secure uniformity in the pages of scientific transactions and serials, so that parts of various publications can be bound together by those interested in particular subjects. The Committee has already issued one report, and has since been taking steps to bring before the various societies which publish *Proceedings* and *Transactions* the advisability of bringing their publications into harmony, so far as size of paper is concerned, with the standard sizes which already prevail in a great majority of scientific journals and almost uniformly in the case of those longest established. As the result of the inquiries the Committee has issued a circular giving the dimensions of the standard octavo and standard quarto size recommended for scientific publications. It is strongly recommended that every article should always begin at the top of a right-hand page, even if that involves a blank left-hand page, so that a paper can be extracted from a journal without mutilating one or two others.

THE Deutsche Seewarte has published a discussion of the storms experienced in the North Atlantic Ocean during the last week of January and the first weeks of February last. It will be remembered that it was during this exceptionally stormy period that the liners *Pavonia* and *Bulgaria* suffered so severely. The investigation shows that very unusual weather extended from the Rocky Mountains across the whole of the North Atlantic to the Ural Mountains, and that the storms over the British Islands and North-west Europe were accompanied by unusually high temperature, and blizzards occurred over the United States. The principal features of the storms were their great intensity and almost uninterrupted succession, and the period was characterised by the relatively southerly position of the zone in which the principal barometric minima occurred, and pursued the easterly direction in which they usually travel. The work has been prepared by Dr. E. Herrmann, and is illustrated by several charts. We understand that the Meteorological Council are also preparing for publication a more elaborate discussion of this stormy period.

THE Central Physical Observatory and the Geographical Society of St. Petersburg sent up an unmanned balloon on March 24, with duly verified meteorograph. The balloon started about 8 a.m.; in the course of an hour it had attained a height of 10 kilometres and was travelling at the rate of 75 kilometres an hour, according to photogrammetric observations made at Pavlovsk Observatory. The balloon was not found until May 9, 700 kilometres to the east of St. Petersburg. The instruments were in good condition, but the trace had suffered from exposure to the weather. The legible portion showed that at starting the temperature was $-3^{\circ}\cdot8$ F.; at 3900 metres it had fallen to $-29^{\circ}\cdot6$, at 4925 metres to $-41^{\circ}\cdot3$, and at 6559 metres to $-60^{\circ}\cdot1$; at 6878 metres the temperature was $-62^{\circ}\cdot9$, while at the highest point shown by the curve, 7223 metres, the reading had risen to $-61^{\circ}\cdot4$.

A REPORT on clock-rates and barometric pressure as illustrated by the mean-time clock and three chronometers at Mare's Island Observatory, together with a brief account of the observatory, is contributed to the *Publications* of the Astronomical Society of the Pacific, No. 68, by Ensign Everett Hayden, of the U.S. Navy. The paper is illustrated by a diagram of the barometer-rate curve of the mean-time clock, and from this and other tables it is inferred that the best chronometers show a remarkably regular change of rate for differences of pressure, running about ·10s. faster for a decrease of ·10-inch of mean barometer. It is suggested that the rate curves of such chronometers should be drawn for a mean pressure of 30·00 inches, with similar curves to the right and left for each tenth lower and higher pressures, respectively, for, say, five-tenths of an inch, for the practical use of navigators.

A LENGTHY paper on the influence of magnetism on the luminescence of gases has been contributed to the *Bulletin de la Classe des Sciences* of the Belgian Academy (part 6), by M. A. de Hemptinne. The author has studied the action of magnetism on tubes without electrodes excited by electric vibrations; and he examines in succession the influence of the pressure of the gas, the length of the electric wave, the nature of the gas, and the influence of the medium. The paper concludes with theoretical considerations relating to the observed facts.

Part 6 of the *Bulletin de la Classe des Sciences* of the Belgian Royal Academy contains a preliminary report from the Belgian Antarctic Expedition on the soundings of the *Belgica*, drawn up by M. Henryk Arctowsky. Between the channels of Tierra del Fuego and the archipelago of Dirck Gherrits a section was taken of the large Antarctic channel which separates the extremities of the Andes from the hypothetical Antarctic continent. Moreover, within the Antarctic circle and on the west of Alexander Land a series of soundings were taken while the ship was drifting with the pack ice. The principal bathymetric discoveries were (1) a deep flat-bottomed basin between the south side of the Andes and the mountain system forming the framework of the lands visited by the expedition; (2) in places a sharp declivity forming a demarcation to the continental plateau; (3) the existence of a continental plateau west of Alexander Land, and south of the 71st parallel.

From Dr. A. Goldhammer we have received copies of notes published by him in *Wiedemann's Annalen* 65 and 67, dealing, one with modern theories of electromagnetic phenomena in iron, nickel and cobalt, and the other with the Zeeman effect. In the former paper the author compares his equations with those obtained by Mr. J. G. Leathem, of Cambridge.

In the *Journal de Physique* for June, M. Coloman de Szily investigates the effect of torsion on the electric resistance of wires. The substance used in the experiments was an alloy called "constantan," whose resistance is but slightly affected by changes of temperature. The general conclusions are: that torsion increases the electric resistance of a wire; that up to the limit of elasticity the increase is roughly proportional to the angle of torsion, but beyond that limit it increases more rapidly; and that the resistance of a twisted wire decreases slowly with the time.

In *Cosmos*, No. 744, M. A. Acloque discusses the affinities between cadelis-flies and moths. The author considers that even if the distance between the Trichoptera and Lepidoptera is not great, there is at the same time a considerable gap separating them, and that little or no light on the question of a previous connection between the two orders is at present afforded by palæontological considerations.

Dr. Felice dell' Acqua, writing in the *Rendiconti del R. Istituto Lombardo*, brings forward considerations, both statistical and hygienic, relative to the consumption of meat food. It would appear that in Milan the average daily consumption of meat amounts to only $154\frac{1}{2}$ grammes per head of population, and this the author considers is insufficient. After pointing out the desirability of paying greater attention to the diet, especially of working people, Dr. dell' Acqua discusses the beneficial effects of a fair proportion of meat on the general physique. The various ways of increasing the supply of meat are considered. Dr. dell' Acqua strongly urges the desirability of breeding more cattle in Italy, and of not slaughtering immature animals. Of other sources capable of yielding greater supply than at present, the author calls attention to fish, rabbits and birds, and he suggests the acclimatisation of foreign animals and even the use of horse-flesh. It would appear that in Italy considerably less animals are slaughtered for food in proportion to the population than in France or Germany, or especially England.

Under the title "The Honey Bee: a Manual of Instruction in Apiculture," by Mr. Frank Benton, the U.S. Department of Agriculture published a very useful *Bulletin* three or four years ago. Twenty-one thousand copies of the manual have been distributed; and the third edition, containing a few additions and changes, has now been published. The magnitude of the apiarian industry in the United States may be judged from the fact that more than 300,000 persons are engaged in the culture of bees, and the present annual value of apiarian products is estimated at 4,000,000*l*. Mr. Benton states, however, that the present existing flora of the United States could support ten times the number of colonies of bees it now supports. An advantage of this branch of agricultural industry is that it does not impoverish the soil in the least, but, on the contrary, results in better seed and fruit crops. For instance, Dr. L. O. Howard points out that recent investigations have shown that certain varieties of peas are nearly or quite sterile unless bees bring pollen from other distinct varieties for their complete cross fertilisation. Mr. Benton's treatise will continue to be of great assistance to persons engaged in the management of bees for profit.

In the *Verhandlungen der k. k. geol. Reichsanstalt*, Nos. 6 and 7, 1899, Dr. M. Remeš deals with the question of palæontological divisions in the Tithonian limestone of Stramberg. This limestone, as is well known, has yielded a varied and specially interesting assemblage of life-forms, including types of both jurassic and cretaceous character, and is to be looked upon as representing a true passage series. The author gives a brief account of the attempts that have been made to distinguish divisions of horizon or organic facies in the Stramberg Beds, and points out that insufficient care has hitherto been exercised in keeping separate the fossils collected from the various exposures in the one neighbourhood. With the results of his own studies as a groundwork, as well as the long experience of his father in the same field of observation, Dr. Remeš is enabled to show the character of the fauna collected from five different exposures, and to point out petrographical similarities and differences. He concludes that the Stramberg limestone forms a uniform mass which, while not satisfactorily showing stratification, permits a division according to facies in its different parts. It is found that a separation of the jurassic fauna with *Terebratula moravica* from the cretaceous fauna with *T. janitor*, as proposed by Hébert, cannot be justified: a mingling of jurassic and cretaceous forms occurs in like manner at all the points examined. The division adopted by Dr. Remeš, according to organic facies, is threefold. He distinguishes a cephalopod-facies (in the Kotouč-Schlossberg rock-complex), a coral- and sponge-facies (Gemeindesteinbruch complex), and an echinoderm-facies (in the red limestone of Nesselsdorf). The passage of these single rock-masses into one another is stated to be gradual.

Dr. Th. Tchistovitch has made the toxic properties of eel-serum the basis of some important investigations on the mechanism of immunity. These researches emanate from the laboratories of Profs. Metchnikoff and Roux at the Paris Pasteur Institute, and are published in the *Annales*. Amongst other interesting facts brought to light is the discovery that during the process of immunising an animal against the toxic effect of eel-serum, although it may be trained to resist increasing quantities of the toxin, the *antitoxic* properties of this animal's blood-serum do not increase; on the contrary, the antitoxin of a greater or less degree of strength elaborated during the early stages of the immunising process steadily declines in antitoxic value as the animal gains in power of resisting the toxin. The presence, therefore, in the blood of an immunised animal of an antitoxin of a greater or less degree of strength cannot be held to furnish any information or standard as to the degree of immunity acquired by that animal. Immunity, therefore, depends not solely on the production of an antitoxin in the blood, but on some other mechanism which Dr. Tchistovitch considers may in all probability be dependent upon the leucocytes.

AN account of an investigation of a fungus which has done serious damage to the cacao industry in Trinidad is given in the *Kew Bulletin* (Nos. 145-146). Mr. J. H. Hart, Superintendent of the Royal Botanic Gardens, Trinidad, sent to Kew material for examination, and the report upon it states:—"Microscopic examination revealed the presence of two distinct fungous parasites, one being the well-known *Phytophthora omnivora*, De Bary, a species closely allied to *Phytophthora infestans*, De Bary, the cause of the potato disease; the other a *Nectria*, which proves to be new to science, and will be known as *Nectria Bainii*, the name suggested by Mr. Hart in compliment to Mr. Bain, who first called attention to the disease. The *Phytophthora* was present on all the pods sent, and may be considered as the cause of the present epidemic in Trinidad. The same, or a closely allied species, appears to be the cause of the cacao-pod disease in Ceylon. The *Nectria* appeared on two pods, and this again possesses many points in common with the *Nectria*, which has caused such destruction to cacao trees in Ceylon by attacking the bark of the trunk and branches, as described by Mr. J. B. Carruthers. At present no mention is made of other than the pod-disease in Trinidad, but the fact of a parasitic *Nectria* being present necessitates the prompt execution of measures calculated to prevent the parasite from extending its ravages." Mr. G. Massee describes each of the species, and states the measures which should be taken to combat the disease.

REPORTS on experiments on the manuring of oats, hay, and potatoes, and on the feeding of sheep, conducted in 1898 on farms in the centre and south-west of Scotland, are contained in the sixth annual report just issued by the agricultural department of the Glasgow and West of Scotland Technical College. The director of the experiments is Prof. R. Patrick Wright, and under his guidance a large amount of serviceable information, similar in character to that obtained at the Agricultural Experiment Stations in the United States, Canada, and elsewhere, has been made known. By a scheme framed by the Scotch Education Department, the Agricultural Department of the College referred to has been merged into the newly-formed West of Scotland Agricultural College; so the present report is the last of its series, though it is hoped that under the new college a considerable development of the scope and usefulness of the work of agricultural education and research will be rendered possible.

VOL. I. No. 12, of the Records of the Botanical Survey of India is occupied by Mr. V. F. Brotherus' Contributions to the Bryological Flora of Southern India. A number of new species of moss are described.

THE first part of the second volume of the British Museum Catalogue of the African Plants collected by Dr. Friedrich Welwitsch, dealing chiefly with the monocotyledons of the collection, by Dr. A. B. Rendle, has been published.

MESSRS. SWAN SONNENSCHEIN AND CO. have published a second impression of "An Introduction to the Study of Zoology" by Mr. B. Lindsay. The volume is intended for readers beginning the study of zoology, and its chief distinctive characteristic is said to rest "in its attempt to present the system of classification by grades in a form suited to the necessities of elementary and popular teaching."

THE number of the *Biologisches Centralblatt* for July 15 contains a very useful summary, by Prof. Moebius, of recent advances in our knowledge of the mode of impregnation in Gymnosperms and other flowering plants, derived from the remarkable observations of Webber, Ikeno, Hirasi, Nawaschin, Guignard, and Lotsy. The paper is illustrated by several figures.

TO the practical engineer Molesworth's "Pocket-book of Useful Formulæ and Memoranda" is invaluable. The fact that the twenty-fourth edition, revised and enlarged, has just been published, indicates the extent to which the book has met with approbation. An entirely new electrical section has been added, and will increase the usefulness of what has long been a very serviceable manual.

*Contributions from the Botanical Laboratory* of the University of Philadelphia, Vol. ii. No. 1, is full of interesting papers. Dr. Lucy L. W. Wilson has some observations on the life-history of *Conopholis americana*, a remarkable American parasitic plant belonging to the Orobancheæ. Elizabeth A. Simons gives the results of a series of experiments on the rate of circumnutation of the growing stem of some flowering plants, which she finds to be considerably more rapid than the rate stated by Darwin. Mr. R. E. B. McKenney describes observations on the development of some embryo-sacs, chiefly *Scilla* and *Hyacinthus*. The present publication affords one among many illustrations of the extent to which scientific research is being carried out by ladies in the United States. Out of nine papers in this number, five are by women.

THE first number of the *Yorkshire Ramblers' Club Journal* is a very creditable production. Original contributions, reviews, illustrations, and reprints of articles which have appeared elsewhere are included, dealing with various phases of activity of the Club. Noteworthy among the subjects dealt with are the mountains and snow fields of Norway, and the caves and potholes of Yorkshire. A large number of the caves in the carboniferous limestone still remain unexplored; and the Club is busily engaged in this almost inexhaustible field of "underground mountaineering" and research. The manner in which the work of exploration has been carried on and the results achieved have already conferred distinction upon the Club, no less than on the members who are its pioneers. We shall look to future numbers of the *Journal* for particulars of new explorations.

SEVERAL publications containing the results of meteorological observations have lately come to hand. From Prof. J. M. Pernter we have received vols. 32, 33-35 of the Jahrbücher of the K.K. Central-Anstalt für Meteorologie und Erdmagnetismus, Vienna, containing tabulated results of daily meteorological observations made in Austria during 1895, 1896 and 1898.—The Jahrbuch of meteorological observations made during 1897 at the observatory attached to the *Magdeburgische Zeitung*, edited by Herr R. Weidenhagen, has, in addition to the usual tables, a number of curves showing graphically some of the results.—The Ergebnisse of hourly observations made at Bremen in 1898, edited by Prof. Paul Bergholz, have been published.—Sir Cuthbert E. Peek has issued his annual statement of meteorological observations made at his observatory, Lyme Regis, during 1898. A special tower has been erected for the anemometers, and upon it are placed a Dines' pressure-tube recording anemometer and a Robinson anemometer, so that the two instruments can now be compared under very favourable conditions.

SEVERAL new editions of scientific works have lately been received. The publication, by Mr. Murray, of the third edition of Mr. Edward Whymper's guide to "The Valley of Zermatt and the Matterhorn" and the fourth edition of "Chamonix and the Range of Mont Blanc" is well-timed. All visitors to Switzerland should provide themselves with one or both of these interesting and serviceable handbooks.—A second edition of Prof. Henry Louis's "Handbook of Gold Milling" has been published by Messrs. Macmillan and Co. The book originally appeared in 1893, since which date great advances have been

made in the art of gold extraction. So far as possible, account has been taken of all important processes in bringing the book up to date.—Dr. David Walsh's volume on "The Röntgen Rays in Medical Work" (Baillière, Tindall, and Cox) contains much information of interest to all who desire to know how far Röntgen rays have been utilised in medical and surgical cases. To the physician and surgeon this second edition should be of great service in showing what has been done. Referring to the progress made since the publication of the first edition, Dr. Walsh says: "In practical work the times of exposure are shorter, results more certain, and the merits of the statical machine more widely recognised."—A second edition of "A Text-book of Applied Mechanics," by Prof. Andrew Jamieson, has been published by Messrs. Charles Griffin and Co., Ltd. This book has been revised and extended, the chief additions being in the part on hydraulics and hydraulic machines.—The case for cremation as a means of disposing of the dead is forcibly stated by Sir H. Thompson in "Modern Cremation" (Smith, Elder, and Co.), the third edition of which, revised and much enlarged, has just been published. The volume brings up to the present date the history of the practice of cremation, and of the work of the Cremation Society of England.

THE additions to the Zoological Society's Gardens during the past week include a Tantalus Monkey (*Cercopithecus tantalus*) from West Africa, presented by Mr. W. Knight; two Hairy Armadillos (*Dasypus villosus*), a Geoffroy's Cat (*Felis geoffroii*) from La Plata, presented by Mr. W. Brown; a Magpie (*Pica rustica*), British, presented by Mr. S. B. Goldsmith; a Red-eared Bulbul (*Pycnonotus jocosus*), a Yellow-bellied Liothrix (*Liothrix luteus*) from India, presented by Miss Petrocochino; two Goshawks (*Astur palumbarius*), European, presented by M. P. A. Pichot; three Spotted Tinamous (*Northura maculosa*) from Buenos Ayres, four Rufous Tinamous (*Rhynchotus rufescens*) from Brazil, presented by Mr. Ernest Gibson; two Black-eared Marmosets (*Hapale penicillata*) from South-east Brazil, two Maholi Galagos (*Galago maholi*) from South Africa, a Sooty Phalanger (*Trichosaurus fuliginosus*) from Tasmania, a Malabar Squirrel (*Sciurus maximus*, var. *dealbatus*) from India, a Long-necked Chelodine (*Chelodina longicollis*) from South Australia, two Serrated Terrapins (*Chrysemys scripta*) from North America, deposited; a Grison (*Galictis vittata*) from South America, two Superb Tanagers (*Calliste fastuosa*), a Blue and Black Tanager (*Tanagrella cyanomelaena*) from Brazil, a Thick-billed Tanager (*Euphonia laniirostris*) from Central America, purchased; a Common Mynah (*Acridotheres tristis*) from India, received in exchange.

## OUR ASTRONOMICAL COLUMN.

HOLMES' COMET, 1899 *d* (1892 III.).—A new ephemeris for this comet is given by Mr. H. J. Zwiers in *Astr. Nach.* (Bd. 150, No. 3582). It is important that as many observations as possible should be secured, in order to provide the necessary data for a more correct determination of the orbit.

*Ephemeris for 12h. Greenwich Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ ″ | Br. $r^{-2}$. | $(r\Delta)^{-2}$. |
|---|---|---|---|---|
| Aug. 10 ... | 2 43 48·80 .. | 34 39 46·4 | | |
| 11 ... | 44 56·27 ... | 34 55 39·6 | | |
| 12 ... | 46 2·64 ... | 35 11 29·8 ... | 0·1940 ... | 0·04674 |
| 13 ... | 47 7·89 .. | 35 27 16·9 | | |
| 14 ... | 48 11·99 ... | 35 43 0·9 | | |
| 15 ... | 49 14·92 ... | 35 58 41·7 | | |
| 16 ... | 50 16·66 ... | 36 14 19·2 ... | 0·1923 ... | 0·04781 |
| 17 ... | 2 51 17·17 ... | 36 29 53·4 | | |

COMET SWIFT (1899 *a*).—Observers still interested in this comet, and possessed of the necessary optical means, will find an extended ephemeris in the *Astr. Nach.* (Bd. 150, No. 3583) by Herr J. Moller, of Kiel. The positions and relative brightness are given up to September 16, but it is only with the largest instruments that the comet can be at all detected.

THE NEW ALGOL VARIABLE.—In *Harvard College Observatory Circular*, No. 44, Prof. E. C. Pickering gives an ephemeris for observations of this recently discovered variable. The following are the predicted minima during the nights of the present month:—

*Heliocentric Minima of B.D.* 45°·3062.

1899, August 11, at 11h. 43m.
,, ,, 20, at 15h. 12m.

The position of the star is
R.A. ... 20h. 2·4m.
Decl. ... + 45° 53′ } (1855),

and its normal magnitude about 8·6.

DOUBLE STAR CATALOGUE.—Mr. R. G. Aitken has communicated to the *Astr. Nach.* (Bd. 150, Nos. 3584–5) his observations of 319 double stars made during the year 1898. The measures were made with the filar micrometer, in conjunction with either the 12-inch or 36-inch refractor, at the Lick Observatory. The star places are all reduced to epoch 1900, and the data given are time of observation, position angle, distance of components, and their individual magnitudes.

ELEMENTS OF COMETARY ORBITS.—M. G. Fayet has extended Oppolzer's "Traités des Orbites," and brought it up to date by giving the approximate elements for the year 1900 of all the comets hitherto observed. The list is divided into three portions, dealing with comets having elliptic, parabolic, and uncertain orbits respectively; 106 comets are given with elliptic elements, and 104 with parabolic elements, the dates of observation extending from 1702 to the present time. Fifty-one comets of uncertain elements are given, extending from 137 B.C. to 1880. This list of cometary elements will be especially useful in referring to the elements of any new comet, to see if it is really a new member of the solar system or a return of one previously recorded.

## THE FUR-SEAL HERDS OF THE NORTH PACIFIC.

FEW commercial industries command a more varied or more widely spread series of interests than does the sealing trade of the North Pacific. In addition to the great biological interest attaching to the seal-herds, we have, first of all, a considerable number of Aleuts dwelling on the islands to drive, kill, and skin the seals, and who subsist to a certain extent on seal-flesh. Then there is the revenue drawn by the American and Russian Governments for the right of sealing on their respective islands, as well as the Customs dues levied by the former on the dressed seal-skins when re-imported into their territory. Not to mention the transport of the raw hides, the dressing of the latter and their conversion into commercial seal-skin forms a very important industry in London, which employs a large number of hands. There are, moreover, the vessels and their crews, which have of late years been engaged in pelagic sealing; a large proportion of which sailed from Canadian ports. Finally, there is the manufacture of the finished seal-skin into garments, and the retail sale of the latter.

From all points of view a cordial welcome should, therefore, be extended to the issue by the United States Government of the official Report of the Commissioner in charge of the fur-seal investigations of 1896–97. This Report, which bears the title of "The Fur-Seals and Fur-Seal Islands of the North Pacific Ocean," is in two parts, and comprises the final results of the investigations carried on by the Commissioner and his associates, as well as the recommendations jointly formulated by the American and British members of the International Commission.

The fur-seals of the Northern Pacific comprise three distinct herds, which are stated to keep strictly apart from one another, having each their own breeding-places, feeding-grounds, and routes of migration. The most important of the three herds is the one resorting for breeding purposes in summer to the islands of St. Paul and St. George in the Pribyloff group, situated on the eastern side of Bering Sea. In winter this herd

passes through the channels of the Aleutian chain into the Pacific, ranging as far south as Southern California, and returning to their summer haunts along the American coast. Next in importance is the Komandorski herd, the members of which breed upon Bering and Medui islands in that group, migrating in winter down the eastern coast of Japan, and returning by the same route the following summer. Smallest of all is the Robben Island herd, now restricted to Robben, or Tiuleni Island, in the Sea of Okhotsk, just south of Saghalien, but which formerly also colonised four islands of the Kurile chain. The line of migration of this herd lies through the Sea of Japan, so that it never enters the open Pacific. Whereas the Pribyloff herd, which is the one to which the present Report, so far as published,[1] mainly refers, is the property of the Government of the United States, the other two belong to Russia. So far as can be ascertained, the Komandorski and Pribyloff herds were unknown to man (except during migration) till the discovery of the former islands by Bering in 1741, and of the latter by Pribyloff in 1786.

Hitherto the seals of all three herds have been regarded as constituting a single species, *Otaria* (or *Callorhinus*) *ursina*, although differences in colour, shape, and the character of the fur have long been known to exist between them. From the complete isolation of the three herds, and the apparent absence of intermediate forms, Dr. Jordan, the American Commissioner, feels justified in regarding them as indicating as many distinct species, the leading characteristics of which are indicated in the Report. The typical *ursina* is represented by the Komandorski herd, while to the Pribyloff form is assigned the name *alascana* (*alascanus* if *Callorhinus* be recognised as a genus) and to the Robben Island seals that of *curilensis*. To our own thinking it would have been better if these three forms had been regarded as subspecies, and that such a classification at one time occurred to Dr. Jordan, seems to be indicated by the circumstance that the page (45) of the Report on which they are described is headed "The Subspecies of Fur-Seal."

The fact that the fur-seals resort every summer in great numbers to the Pribyloffs for breeding purposes is doubtless well known to the great majority of our readers, but as some new facts in regard to their period of residence on the islands and their habits while there are recorded in the Report, a brief sketch of this period of their existence may not be out of place.

The old breeding "bulls" are the first to put in an appearance, their average date of landing being about the first of May. The younger bulls do not land till the arrival of the "cows," when they "haul out" and pass round the "rookeries" to places in the rear, or fight their way through the territories of the old bulls in possession. The "bachelors," or immature males, begin to arrive about the same time as the old bulls, usually making their appearance according to age; the smaller seals beginning to predominate after July 9. The older bachelors being alone killed in the Pribyloffs, as many as possible are slaughtered before the arrival of their younger brethren, regular driving usually commencing about June 1. It is about June 10 that the adult cows begin to arrive, their appearance and landing, like that of the adult bulls, being gradual. Their arrival is not, as has been stated to be the case, an occasion of fighting among the old bulls for their possession. As a rule, a female about to land reconnoitres the shore by swimming backwards and forwards, and then lands on the rocks, where she is immediately taken in charge by the nearest bull. If a bull discovers her while attempting to land, she endeavours to escape; but if this is impracticable, she submits and takes her station on shore beside him. When a bull once obtains a cow, his station becomes an objective point for all the others landing in the vicinity, and a "harem" is thus formed; large "harems" being thus constituted in the neighbourhood of favourite landing-places. Soon after landing the cows give birth to their "pups" (one in number to each cow).

In the larger rookeries as many as a hundred cows may go to the formation of a single harem; and so long as they remain quietly resting before and after the birth of their pups, the one bull has no difficulty in keeping them under control. But as soon as the pairing-season sets in (which it does very soon after the birth of the pups) the old bull is unable to manage his harem, and the "idle bulls" around enter the circle. With the "podding" (collection in masses) and scattering of the pups and the influx of fresh cows, the area occupied by the seals gradually extends, and fresh bulls are taken into the circle, until the utmost limits of expansion are reached.

The population of breeding cows gradually increases from the beginning of the season till about the middle of July, from which period it diminishes till the close of the breeding-season, about August 1, the height of the season being about July 15, when the maximum number of breeding cows are on shore. It is not, however, to be assumed that by any means all the cows are then on land—quite the contrary. From about June 10 or 12 onwards fresh cows are constantly arriving at the rookeries, each cow making a sojourn of about ten or twelve days, after which she starts on her first excursion to the feeding-grounds, distant between one and two hundred miles. The height of the season accordingly means merely that the stream of arriving cows is about counterbalanced by the departing one.

Throughout the breeding-season a band of sleeping, playing, and swimming seals skirts the sea-front of each rookery, the majority of these being cows, although some are bachelors. This band includes the arriving and departing cows; the former gradually edging themselves nearer and nearer to the shore, while the latter tend to the seaward fringe. So stealthily is the landing and the departure accomplished, that it is a very difficult matter to observe a cow either in the act of landing or of setting out to sea. One reason of the loitering before landing seems to be to allow time for the complete digestion of the food, which always takes place while at sea. As the bachelors likewise make periodical journeys to the feeding-grounds, it is evident that it is only the bulls which fast throughout the breeding-season; and for the purpose of enduring this, they accumulate a thick layer of blubber previous to landing.

On landing from one of her feeding expeditions the cow calls lustily for her pup, on finding which she forthwith proceeds to nurse it, the pup then departing and taking no further notice of its parent till it again requires a meal. As the majority of the cows are at sea, a landing cow is immediately surrounded by hungry, and it may be starving, pups, who are driven away with decidedly savage treatment. The pups are entirely dependent upon their own mother's milk till about November, the Commission scouting the idea that there is any promiscuous feeding of the pups by the cows, or that the former subsist in part on a vegetable diet.

Mention remains to be made of the landing of the yearling and two-year-old females, whose brothers come to the islands about the first of July and spend their time on the hauling grounds. The two-year-old females reach the rookeries about August 1, and take up their places either in the old harems, or in fresh ones in front of and behind the regular breeding-grounds. Here they are taken charge of by young bulls, and after a short sojourn return to the water. Although the yearling cows apparently arrive with the two-year-olds, they do not make their appearance on the rookeries much before September, and then spend their time in ranging over the latter and playing with the pups, which by this time have become strong swimmers.

In regard to the breaking up of the breeding-season, the old harem-bulls, who have fasted from the beginning of May, begin to desert the rookeries for the feeding-grounds about July 25, their places being taken by the idle bulls. By some time between August 5 and 10, all the adult bulls have departed; the breeding-grounds being then occupied by the younger bulls and bachelors, who, however, soon return to the sand beaches. At the first approach of winter, which usually occurs in November, the cows and pups start on their journey southward. The bachelors linger for some time longer, in some years a considerable number remaining till the end of December or even well on in January; while in mild seasons some may be seen all through the winter. As a rule, however, November ends the sojourn of the seals on the Pribyloffs, and, class by class, they set out on their winter migration.

Such is, very briefly, the life-history of the fur-seals during their sojourn around and on the Pribyloffs. We now proceed to notice, with equal brevity, the decline which has of recent years taken place in the numbers of the herd, the reasons for such decline, and the remedies suggested for its recovery. Since these islands came under the sway of the United States Government only bachelors of a certain age have been allowed to be killed on shore. From 1869 to 1889 the sealing rights were leased to the Alaska Commercial Company, whose annual quota of skins was limited to 100,000, of which 75,000 were to be taken on St. Paul and the remainder on St. George. On

[1] Two other parts of the Report are announced, the second (iv.) of which will deal with the Komandorski and Robben Island herds.

the expiration of this lease the islands were relet for a period of twelve years to the North American Commercial Company, on more advantageous terms, the quota of skins being fixed for the first year at 60,000, while it has since been under the regulation of the Secretary to the Treasury.

Putting aside for subsequent mention the question of pelagic sealing, it may be observed that between the years 1871 and 1875 the number of breeding seals and young on the islands was estimated by Mr Elliott, in round numbers, at 3,193,000. In spite, however, of the fact that this observer did not recognise that only a portion of the cows were on land at any one time, the Commission concludes that this estimate is far too high, and that 1,400,000 would have been a much closer approximation to the truth. They further state that between 600,000 and 700,000 seems to be a fair estimate of the number of breeding females resorting annually to the islands between the years 1871 and 1885; while at the present time (1896–97) the number is only about one fifth of what it then was.

As regards the decline of the Pribyloff herd, the best evidence is afforded by the fact that whereas between the years 1871 and 1885 no difficulty was experienced in obtaining the full number of 100,000 bachelor seals of the proper age before July 20, in 1896 it was only found possible to obtain 30,000 fit for killing even by continuing the drives till July 27; while in the following year, when driving was carried on as late as August 11, only 20,890 were obtained. It is largely on these data that the above-mentioned estimate of the former number of breeding animals is founded.

The life of the female seal being estimated at from ten to fifteen years, thirteen years may be taken as an average, during ten of which she is capable of producing young. On this estimate 10 per cent. of the breeding females die of old age each winter, in addition to those which perish from other causes. The stock is replenished by the annual addition of the three-year-old females. Among the young and pups the death-rate from natural causes is very high; about two-thirds thus perishing annually before they attain the age of three years, when the females are fit for breeding and the males for killing. The most important of such natural causes are the presence of a parasitic worm on the sandy breeding-grounds, the trampling to death by the ordinary movements or fights of the adults, starvation of the pups from being separated from their mothers at a very early age, destruction by the killer-whale, and drowning during the winter storms.

In 1896 the number of females with pups on the islands was about 157,000, and in the following year 130,000. In certain rookeries the number of pups had diminished from about 16,240 in 1896 to about 14,320 in 1897, indicating a decrease of about 12 per cent., the number of harems having likewise diminished by about $10\frac{1}{2}$ per cent. Although precise figures are not available, the total decrease in the number of breeding females for the same period may be put down at about 15 per cent., and that of the males fit for killing at about 30 per cent.

Although the exact number to which it is safe to reduce the breeding bulls in a rookery as compared to the cows has not yet been ascertained, it is quite certain that in the Pribyloff herd there is no reduction of the former to anything near that limit. Consequently the killing carried on in the islands cannot be held responsible for the serious reduction which has of late years taken place in the numbers of the herd. On the contrary, such thinning out of the bachelors has tended to the actual increase of the breeding herd, owing to the less amount of fighting which takes place when the bulls are reduced in number, and the consequent diminished loss of life among the cows and pups owing to such fights.

On the other hand, there is every reason for believing that the waning of the herd is solely to be attributed to pelagic sealing, in which the number of females taken is very largely in excess of the males, while for each female so killed an unborn pup is also destroyed, and in the case of those which have already bred a second pup is starved miserably to death on land. Since the normal rate of increase of the breeding herd is a little short of 17 per cent., while the natural death-rate from old age is not far from 10 per cent., it follows (without allowing for other natural causes of death among the adults) that not more than about 6-2/3 per cent. of the females can be destroyed by human agency year by year without involving the ultimate destruction of the herd. This limit has been very largely exceeded as the result of pelagic sealing, in which (in spite of statements to the contrary) it is impossible to distinguish females from males until too late; and in consequence of this the Pribyloff herd has been so reduced that neither pelagic nor land sealing yields an adequate profit on the money invested. The Commission, indeed, go so far as to say that from a commercial point of view the herd is virtually destroyed. "But this," they add, "has not involved the biological destruction of the herd. Under wise protection it may regain its former numbers." That such protection (which involves the prohibition of the killing of females, and therefore apparently also of pelagic sealing[1]) may be extended to the herd while there is yet time, must be the hope of every naturalist. R. L.

## *INHERITANCE OF LONGEVITY IN MAN.*

THE object of this paper[2] is twofold, namely:—

(1) To ascertain whether duration of life is inherited, and

(2) To exhibit natural selection at work in man.

According to both Wallace and Weismann the duration of life in any organism is determined by natural selection. An organism lives so long as it is advantageous, not to itself, but to its species that it should live. But it would be impossible for natural selection to determine the fit duration of life, as it would be impossible for it to fix any other character, unless that character were inherited. Accordingly a preliminary inquiry as to whether duration of life is inherited or not seems needful before we consider further the plausibility of Wallace and Weismann's hypothesis. The present paper shows that directly and collaterally duration of life is certainly inherited in the male line. We believe this to be the first quantitative measure of the inheritance of life's duration. Further data for the inheritance of this character in the female line, and for the study of the inheritance of "brachybioty" or shortlivedness as distinguished from longevity are now being collected. We point out in the paper and endeavour to illustrate by examples the importance of such quantitative measure of the inheritance of life's duration for actuarial practice.

The second aim of our paper seems to us, perhaps, to have the greater scientific importance. In the presidential address at the Oxford meeting of the British Association we were told that no one had seen natural selection at work. In a criticism then published by one of us, it was suggested that every one who had examined a mortality table had seen natural selection at work. Now the meaning of natural selection is absolutely simple. All individuals die, but some, better suited by their constitution and characters to their environment than others, survive longer, and so are able, or better able, to reproduce themselves, and to protect for a longer period their offspring. To assert that natural selection does not exist, is to assert that the whole death-rate is non-selective, or is not a function of the constitution and characters of the individual. Looked at from this standpoint the existence of natural selection really becomes a truism. All that remains when we desire to see it at work is to determine the relative amounts of the selective and non-selective parts of the death-rate for individuals living under the like environment. If, therefore, individuals living under much the same conditions are dealt with, the determination of the selective and non-selective death-rates is a measure of the quantitative amount of natural selection. Now we can answer this problem in two ways. First we may take any organ, and determine whether the death-rate is a function of the size of this organ. This method, adopted by Prof. Weldon, would be the direct and best method, if the results were not apt to be screened by other factors. In the first place we have to hit upon some organ upon which vitality largely and sensibly depends; and this is not easy, for constitutional power of resisting the attacks of disease may depend upon, not one organ, but on the complex relationships of a system of organs, and in the next place the whole problem is rendered difficult by changes due to growth. In the second method we do not attempt to select any organ whatever, but select individuals having any general

[1] The writer takes this opportunity of mentioning that, misled by a summary of some of the evidence given before the Paris Commission, he was inclined in the "Royal Natural History" to pronounce pelagic sealing more humane than seal-killing on land.

[2] "Data for the Problem of Evolution in Man. II. A First Study of the Inheritance of Longevity and the Selective Death-rate in Man." By Miss Mary Beeton and Karl Pearson, F.R.S., University College, London. Received May 29. (Abstract of a paper read before the Royal Society, June 15.)

resemblance in their constitution, or in the whole complex of organs and characters, and correlate their fitness for surviving. Now relations or members of the same family are precisely such individuals. If there were no selective death-rate there would be no correlation between the ages of death of, say, brothers. If there were no non-selective death-rate, we ought to find that the correlation between ages of death of brothers takes the value determined for the coefficient of heredity in brothers, *e.g.* the ·4 of stature, fore-arm, cephalic index, eye colour, &c., Actually we find it to be something sensibly less than ·4. Our investigation shows that, in round numbers, about 80 per cent. of the death-rate is selective in the case of mankind. To that extent natural selection is actually at work. Combined with the quantitative measures of heredity already published, or obtained if not yet published, we can safely conclude that Darwin's theory of a progressive change due to natural selection combined with heredity applies even to mankind to an extent which can be quantitatively measured. The next stage must be an experimental one. Various types of life ought to be submitted to ordeals of a kind like to those which occur in nature, and the correlation between the powers of resistance to these ordeals existing in members of the same family or brood determined. We shall thus be able to ascertain under a variety of circumstances the relative proportions of the selective and non-selective death-rates. A careful inspection of the characters of the longer-lived families may possibly enable the trained biologist to select some organs or characters to which a direct application of Prof. Weldon's method can be made, and thus enable us to distribute, so to speak, the total selective death-rate previously discovered among its chief factors; but here it must be remembered that relationship of organs may be quite as important as absolute size. The present paper is merely a preliminary study of the selective death-rate in man; but one may venture to express a hope that in a comparatively few years, if enough workers can be found for the experimental side of the subject, we shall no longer hear natural selection spoken of as hypothetical, but rather its quantitative measure given for various organisms under divers environments.

## THE CAUSE AND PREVENTION OF MALARIA.[1]

I HAVE the honour to address you, on completion of my term of special duty for the investigation of malaria, on the subject of the practical results as regards the prevention of the disease which may be expected to arise from my researches; and I trust that this letter may be submitted to Government if the Director General thinks fit.

It has been shown in my reports to you that the parasites of malaria pass a stage of their existence in certain species of mosquitoes, by the bites of which they are inoculated into the blood of healthy men and birds. These observations have solved the problem—previously thought insolvable—of the mode of life of these parasites in external nature.

My results have been accepted by Dr. Laveran, the discoverer of the parasites of malaria; by Dr. Manson, who elaborated the mosquito theory of malaria; by Dr. Nuttall, of the Hygienic Institute of Berlin, who has made a special study of the relations between insects and disease; and, I understand, by M. Metchnikoff, Director of the Laboratory of the Pasteur Institute in Paris. Lately, moreover, Dr. C. W. Daniels, of the Malaria Commission, who has been sent to study with me in Calcutta, has confirmed my observations in a special report to the Royal Society; while, lastly, Prof. Grassi and Drs. Bignami and Bastianelli, of Rome, have been able, after receiving specimens and copies of my reports from me, to repeat my experiments in detail, and to follow two of the parasites of human malaria through all their stages in a species of mosquito called the *Anopheles claviger*.

It may, therefore, be finally accepted as a fact that malaria is communicated by the bites of some species of mosquito; and, to judge from the general laws governing the development of parasitic animals, such as the parasites of malaria, this is very probably the only way in which infection is acquired, in which opinion several distinguished men of science concur with me.

In considering this statement it is necessary to remember that it does not refer to the mere recurrences of fever to which people previously infected are often subject as the result of chill, fatigue, and so on. When I say that malaria is communicated by the bites of mosquitoes, I allude only to the original infection.

It is also necessary to guard against assertions to the effect that malaria is prevalent where mosquitoes and gnats do not exist. In my experience, when the facts come to be inquired into, such assertions are found to be untrue. Scientific research has now yielded so absolute a proof of the mosquito theory of malaria that hearsay evidence opposed to it can no longer carry any weight.

Hence it follows that, in order to eliminate malaria wholly or partly from a given locality, it is necessary only to exterminate the various species of insect which carry the infection. This will certainly remove the malaria to a large extent, and will almost certainly remove it altogether. It remains only to consider whether such a measure is practicable.

Theoretically the extermination of mosquitoes is a very simple matter. These insects are always hatched from aquatic larvæ or grubs which can live only in small stagnant collections of water, such as pots and tubs of water, garden cisterns, wells, ditches and drains, small ponds, half-dried watercourses, and temporary pools of rain-water. So far as I have yet observed the larvæ are seldom to be found in larger bodies of water, such as tanks, rice-fields, streams and rivers and lakes, because in such places they are devoured by minnows and other small fish. Nor have I ever seen any evidence in favour of the popular view that they breed in damp grass, dead leaves, and so on.

Hence, in order to get rid of these insects from a locality, it will suffice to empty out or drain away, or treat with certain chemicals, the small collections of water in which their larvæ must pass their existence.

But the practicability of this will depend on circumstances—especially, I think, on the species of mosquito with which we wish to deal. In my experience, different species select different habitations for their larvæ. Thus the common "brindled mosquitoes" breed almost entirely in pots and tubs of water; the common "grey mosquitoes" only in cisterns, ditches and drains; while the rarer "spotted-winged mosquitoes" seem to choose only shallow rain-water puddles and ponds too large to dry up under a week or more, and too small or too foul and stagnant for minnows.

Hence the larvæ of the first two varieties are found in large numbers round almost all human dwellings in India; and, because their breeding grounds—namely, vessels of water, drains and wells—are so numerous and are so frequently contained in private tenements, it will be almost impossible to exterminate them on a large scale.

On the other hand, spotted-winged mosquitoes are generally much more rare than the other two varieties. They do not appear to breed in wells, cisterns and vessels of water, and therefore have no special connection with human habitations. In fact it is usually a matter of some difficulty to obtain their larvæ. Small pools of any permanence—such as they require—are not common in most parts of India, except during the rains, and then pools of this kind are generally full of minnows which make short work of any mosquito larvæ they may find. In other words, the breeding grounds of the spotted-winged varieties seem to be so isolated and small that I think it may be possible to exterminate this species under certain circumstances.

The importance of these observations will be apparent when I add that hitherto the parasites of human malaria have been found only in spotted-winged mosquitoes—namely, in two species of them in India and in one species in Italy. As a result of very numerous experiments I think that the common brindled and grey mosquitoes are quite innocuous as regards human malaria—a fortunate circumstance for the human race in the tropics. And Prof. Grassi seems to have come to the same conclusion as the result of his inquiries in Italy.

But I wish to be understood as writing with all due caution on these points. Up to the present our knowledge, both as regards the habits of the various species of mosquito and as regards the capacity of each for carrying malaria, is not complete. All I can now say is that if my anticipations be realised—if it be found that the malaria-bearing species of mosquito multiply only in small isolated collections of water which can easily be dissipated—we shall possess a simple mode of eliminating malaria from certain localities.

I limit this statement to certain localities only, because it is obvious that where the breeding pools are very numerous,

[1] Report from Major Ronald Ross to the Secretary to the Director General, Indian Medical Service, Simla. Dated Calcutta, February 16.

as in water-logged country, or where the inhabitants are not sufficiently advanced to take the necessary precautions, we can scarcely expect the recent observations to be of much use—at least for some years to come. And this limitation must, I fear, exclude most of the rural areas in India.

Where, however, the breeding pools are not very numerous, and where there is anything approaching a competent sanitary establishment, we may, I think, hope to reap the benefit of these discoveries. And this should apply to the most crowded areas, such as those of cities, towns and cantonments, and also to tea, coffee, and indigo estates, and perhaps to military camps.

For instance, malaria causes an enormous amount of sickness among the poor in most Indian cities. Here the common species of mosquitoes breed in the precincts of almost all the houses, and can therefore scarcely be exterminated; but pools suitable for the spotted-winged varieties are comparatively scarce, being found only on vacant areas, ill-kept gardens, or beside roads in very exceptional positions where they can neither dry up quickly nor contain fish. Thus a single small puddle may supply the dangerous mosquitoes to several square miles containing a crowded population: if this be detected and drained off—which will generally cost only a very few rupees—we may expect malaria to vanish from that particular area.

The same considerations will apply to military cantonments and estates under cultivation. In many such malaria causes the bulk of the sickness, and may often, I think, originate from two or three small puddles of a few square yards in size. Thus in a malarious part of the cantonment of Secunderabad, I found the larvæ of spotted-winged mosquitoes only after a long search in a single little pool which could be filled up with a few cart-loads of town rubbish.

In making these suggestions I do not wish to excite hopes which may ultimately prove to have been unfounded. We do not yet know all the dangerous species of mosquito, nor do we even possess an exhaustive knowledge of the haunts and habits of any one variety. I wish merely to indicate what, so far as I can see at present, may become a very simple means of eradicating malaria.

One thing may be said for certain. Where previously we have been unable to point out the exact origin of the malaria in a locality, and have thought that it rises from the soil generally, we may now hope for much more precise knowledge regarding its source; and it will be contrary to experience if human ingenuity does not finally succeed in turning such information to practical account.

More than this, if the distinguishing characteristics of the malaria-bearing mosquitoes are sufficiently marked (if, for instance, they all have spotted wings), people forced to live or travel in malarious districts will ultimately come to recognise them and to take precautions against being bitten by them.

Before practical results can be reasonably looked for, however, we must find precisely—

(*a*) What species of Indian mosquitoes do and do not carry human malaria.

(*b*) What are the habits of the dangerous varieties.

I hope, therefore, that I may be permitted to urge the desirability of carrying out this research. It will no longer present any scientific difficulties, as only the methods already successfully adopted will be required. The results obtained will be quite unequivocal and definite.

But the inquiry should be exhaustive. It will not suffice to distinguish merely one or two malaria-bearing species of mosquito in one or two localities; we should learn to know all of them in all parts of the country.

The investigation will be abbreviated if the dangerous species be found to belong only to one class of mosquito, as I think is likely; and the researches which are now being energetically entered upon in Germany, Italy, America and Africa will assist any which may be undertaken in India, though there is reason for thinking that the malaria-bearing species differ in various countries.

As each species is detected it will be possible to attempt measures at once for its extermination in given localities as an experiment.

I regret that, owing to my work connected with *kala-azar*, I have not been able to advance this branch of knowledge as much during my term of special duty as I had hoped to do; but I think that the solution of the malaria problem which has been obtained during this period will ultimately yield results of practical importance.

## *UNIVERSITY AND EDUCATIONAL INTELLIGENCE.*

THE *Times* reports that the University of Berlin celebrated on Thursday last the ninetieth anniversary of its foundation by Frederick William III. The oration was delivered by the retiring rector, Dr. Waldeyer, professor of anatomy, who took for his text the question, "Does the University of Berlin fulfil the mission entrusted to it by its founder?" As a contribution to the discussion of this question, he gave a learned and interesting account of the history of anatomical teaching in Berlin. Dr. Waldeyer is succeeded as rector by Prof. Fuchs, the distinguished mathematician.

THE Research Fellowships founded by the Salters' Company and the Leathersellers' Company for the encouragement of higher research in chemistry in its relation to manufactures, tenable at the City and Guilds Central Technical College, being now vacant, the Executive Committee of the City and Guilds of London Institute will, before the commencement of next session, consider applications and elect candidates. The grant made by each of the companies to the Institute for this purpose is 150*l.* a year. Copies of the schemes under which the Fellowships will be awarded may be had on application to the Honorary Secretary of the Institute, Gresham College, Basinghall Street, E.C.

A COPY of the twenty-third annual "Catalogue" of the Agricultural and Mechanical College of Texas has been received. All the departments of the College appear to be well equipped, and the buildings and grounds are of a very extensive character. The course of work at the College is designed to enable young men "to obtain that education and training which will fit them to take a leading part in the material development of the State; to become scientific farmers and horticulturists, familiar with the properties and needs of soils, the laws of plant growth, the principles of breeding, and, in general, with rational methods based on the revelations of modern science; to become mechanical engineers, draughtsmen, chemists, civil engineeers, competent to fill responsible positions in these callings—men fitted not only to meet demands made upon them, but to create such demand by pointing the way to progress and development."

THE Royal Naval Engineering College at Keyham was visited by members of the Institution of Mechanical Engineers during the recent meeting at Plymouth, and the excellent opportunities afforded for the efficient training of the engineer students, who are being instructed both theoretically and practically to enable them to become engineer officers in the Royal Navy, were seen. For the last eleven years Keyham has been the only Admiralty training ground for these officers. An entry is made once each year, during the first or second week in July, following a competitive examination held by the Civil Service Commissioners in the previous April. The period of training is five years. Throughout this time they undergo an educational course at the Royal Naval Engineering College under Prof. A. M. Worthington, F.R.S., whilst their practical training is obtained in the dockyard at Keyham, and the work they perform is as far as possible real. In a paper read before the Institution of Mechanical Engineers, Mr. R. Mayston pointed out that the facilities afforded at Keyham for the acquirement of a thoroughly practical training place the Royal Naval Engineering College in the foremost rank as an institution for obtaining a sound knowledge of mechanical engineering. The fact that as soon as possible after entry the student is employed on useful work, the various courses of instruction which are arranged to render the knowledge of marine engineering obtained as complete and as comprehensive as possible, the facilities afforded for acquaintance with running machinery, the constant contact throughout the training with experienced workmen, the frequent opportunities afforded for obtaining information from the officers who have charge of the training, all go to indicate that nothing is spared to make the training of the engineer student as complete as possible. It may, indeed, be accurately said that Keyham College furnishes an example of what technical education should mean, namely, a wise combination of theoretical and practical work.

HER Majesty's Commissioners for the Exhibition of 1851 have made the following appointments to Science Research Scholarships for the year 1899, on the recommendation of the authorities of the respective Universities and Colleges. The scholarships are of the value of 150*l.* a year, and are ordinarily tenable for two years (subject to a satisfactory

report at the end of the first year) in any University at home or abroad, or in some other institution approved of by the Commissioners. The scholars are to devote themselves exclusively to study and research in some branch of science, the extension of which is important to the industries of the country. A limited number of the scholarships are renewed for a third year where it appears that the renewal is likely to result in work of scientific importance.

| | Nominating institution | Scholar |
|---|---|---|
| 1 | University of Glasgow | Robert John Tainsh Bell |
| 2 | University of St. Andrews | James C. Irvine |
| 3 | Mason University College, Birmingham | Henry Leonard Heathcote |
| 4 | University College, Bristol | Winifred Esther Walker |
| 5 | Yorkshire College, Leeds | Frederick William Skirrow |
| 6 | University College, Liverpool | Charles Glover Barkla |
| 7 | University College, London | Harriette Chick |
| 8 | University College, London | Henry James Tomlinson |
| 9 | Owens College, Manchester | Frank Austin Lidbury |
| 10 | Durham College of Science, Newcastle-upon-Tyne | William Campbell |
| 11 | University College, Nottingham | Louis Lownds |
| 12 | University College of Wales, Aberystwyth | James Travis Jenkins |
| 13 | University College of North Wales, Bangor | Robert Duncombe Abell |
| 14 | Queen's College, Belfast | William Caldwell |
| 15 | McGill University | William Brown McLean |
| 16 | University of Melbourne | Bertram D. Steele |

The following scholarships granted in 1898 have been continued for a second year on receipt of a satisfactory report of work done during the first year:—

| | Nominating iostitution | Scholar | Place of study |
|---|---|---|---|
| 1 | University of Glasgow | James Frank Bottomley | Owens College; to proceed to University College, London |
| 2 | University of Aberdeen | Alexander Findlay | University of Leipzig |
| 3 | Mason College, Birmingham | A. H. Reginald Buller | Botanical Institute, Leipzig; to proceed to University of Munich |
| 4 | Yorkshire College, Leeds | Harry Thornton Calvert | University of Leipzig |
| 5 | University College, Liverpool | Ernest Brown | Central Technical College, South Kensington |
| 6 | Owens College, Manchester | James Henry Smith | Owens College (*permitted under special circumstances*) |
| 7 | Durham College of Science, Newcastle-upon-Tyne | Arthur William Ashton | University College, London |
| 8 | University College, Nottingham | Austin Henry Peake | Cavendish Laboratory, Cambridge |
| 9 | Royal College of Science for Ireland | Robert L. Wills | Cavendish Laboratory, Cambridge |
| 10 | Queen's College, Galway | Hugh Ryan | University of Berlin |
| 11 | University of Toronto | William Gabb Smeaton | University of Leipzig |
| 12 | Dalhousie University, Halifax, Nova Scotia | Ebenezer Henry Archibald | Harvard University |

The following scholarships granted in 1897 have been exceptionally renewed for a third year:—

| | Nominating institution | Scholar | Place of study |
|---|---|---|---|
| 1 | University of Glasgow | James Muir | Engineering Laboratory, Cambridge |
| 2 | University of St. Andrews. | Harry McDonald Kyle | Gatty Marine Laboratory, St. Andrews, Laboratoire Arago, Banyuls-sur-mer; Konigliche Biologische Anstalt, Heligoland |
| 3 | University College, Bristol | Charles Henry Graham Sprankling | Owens College, Manchester |
| 4 | Yorkshire College, Leeds | Harold Albert Wilson | Cavendish Laboratory, Cambridge |
| 5 | University College of South Wales and Monmouthshire | Maria Dawson | Botanical Laboratory, Cambridge |
| 6 | University of Melbourn | Walter Rosenbain | Engineering Laboratory, Cambridge |

IN connection with the article on the duties of provincial professors, which recently appeared in these columns, it is worthy of note that, according to the *Hochschul-Nachrichten*, 22 per cent. of the professors in the German universities are engaged in lecturing or laboratory supervision two to six hours a week, and 51 per cent. from seven to twelve hours. Of the associate professors 60 per cent. are engaged from two to six hours per week, and of the privatdocents 82 per cent. Only 4 per cent. of all privatdocents are engaged in lecturing or laboratory supervision more than twelve hours a week. As *Science* remarks, the leisure of the German associate professors and docents explains in large measure the amount of research work accomplished in German universities.

## SCIENTIFIC SERIAL.

*American Journal of Mathematics*, vol. xxi, No. 3, July.—This number opens with a long memoir (64 pp.) by Dr. L. E. Dickson, entitled "Determination of the Structure of all Linear Homogeneous Groups in a Galois Field which are defined by a Quadratic Invariant." This is an attempt at a complete determination of this important type of groups. Dr. Dickson's work is familiar to the students of "groups" in this country by his papers in the *Quarterly Journal* (on the first hypoabelian group generalised, 1898), in the American *Bulletin* (the structure of the hypoabelian groups, July 1898, also of the *Bulletin* for February and May 1898), and in the *Proc. of the Lond. Math. Soc.* (the structure of certain linear groups with quadratic invariants, vol. xxx. pp. 70-98). Two new systems of simple groups are obtained in the present memoir, and thereby some results in the earlier papers are correlated and completed. (References are freely given to results obtained by other workers in this field.)—Upon the ruled surfaces generated by the plane movements whose centrodes are congruent conics tangent at homologous points, by Dr. E. M. Blake. The movements considered are thus defined. Upon a plane $\alpha'$ containing a conic C′ moves a coincident plane $\alpha$, containing a conic C congruent to C′, in such a manner that C and C′ are always tangent at homologous points, *i.e.* C and C′ are the centrodes of the movement. The locus of a point rigidly attached to $\alpha$ is a curve of the fourth order when C and C′ are central conics, and of the third order when they are parabolas. The locus is in a plane parallel to $\alpha'$, and the same distance from it that the generating point is from $\alpha$. The locus of a straight line carried by $\alpha$ and making an angle with it, is a quartic scroll when the centrodes are central conics, and a cubic scroll when they are parabolas. The object of the paper is to describe the forms of these scrolls, and the character and situation of their nodal lines and pinch-points. The results are to be regarded (1) as furnishing a method of mechanically generating certain cubic and quartic scrolls, and (2) as exhibiting the totality of line-loci of the movements considered. These results are believed, by the author, to be new.—The remaining two papers are by J. C. Glashan, and their nature is indicated by their titles, viz. "Quinquisection of the Cyclotomic Equation" (read, in abstract, at the British Association meeting of August 29, 1897, *cf.* Prof. Cayley's paper on the subject in vol. xii. of the *L. Math. Soc. Proc.*), and on the *m* fold section of the cyclotomic equation in the case of *m* prime. (Useful references are given to previous memoirs on the subject.)—Accompanying this number is an index to volumes xi.-xx.—The editorial staff is announced to consist of Prof. Newcomb, with the co-operation of A. Cohen, Frank Morley, Charlotte A. Scott, and other mathematicians.—This is strong enough for any work that may be placed before it.

## SOCIETIES AND ACADEMIES.

### LONDON.

**Royal Society**, June 15.—"On the Waters of the Salt Lake of Urmi." By R. T. Günther, M.A., and J. J. Manley, Daubeny Curator, Magdalen College. Communicated by Sir John Murray, F.R.S.

This paper contains an account of a physical and chemical investigation of the waters of the great salt lake of Urmi in Azerbaijan, North-west Persia. Samples of the water were

collected by Mr. R. T. Günther during his expedition to the lake last summer, and were examined by Mr. J. J. Manley in the laboratory of Magdalen College, Oxford. The specific gravity of one of the samples of the water at 15° C. was about 1·11338; its boiling point under normal conditions in a platinum bottle was 103·84° C., as determined by a form of platinum resistance thermometer. The refractive index ($\mu$) was found to be 1·36110 by a method which the authors consider to be applicable to ordinary sea waters, and to be capable of yielding an indication of the physical nature of the water which is both more accurate and more readily obtainable than the ordinary specific gravity. The chemical examination was, with a slight modification, similar to that employed by Dittmar in his work on the composition of the ocean water collected by the *Challenger*. The hypothetical proximate composition of 100 parts of the total salts was calculated with the following results:—

| | |
|---|---|
| Sodium chloride ... ... | 86·332 |
| Magnesium chloride ... ... | 6·661 |
| Magnesium sulphate ... ... | 4·211 |
| Calcium sulphate ... ... | 0·988 |
| Potassium sulphate ... ... | 1·741 |
| | 99·933 |

A trace of barium was detected by the spectroscope. No iodine or bromine could be discovered.

It is to be hoped that the constitution of the lake water will be determined again at intervals of a few years, in order to show whether or not the salinity is undergoing any change, and if so, in which direction.

PARIS.

**Academy of Sciences**, July 31.—M. van Tieghem in the chair.—The Perpetual Secretary announced to the Academy the loss it had sustained by the death of M. Rieggenbach, correspondent in the Section of Mechanics.—Thermogenesis and use of energy by man in raising and lowering his own weight, by M. A. Chauveau. The positive work done by the animal motor is shown by experiment to take from the animal heat an amount quantitatively equal to the mechanical work produced. When the subject does negative work in the calorimeter, the heat produced is much greater than should arise from the normal physiological work of the organism.—On the law of pressures in gun-muzzles, by M. E Vallier. The author applies the formula previously given by him to the discussion of some experiments by M. Zaboudski, and introduces certain simplifications into his original expression.—Hypodermic impregnation in the *Haementaria castata* of Müller (*Placobdella catenigera* of R. Blanchard), by M. A. Kowalevsky.—On the annular nebula in Lyra, from observations made at the Observatory of Toulouse, by MM. Bourget, Montangerand, and Baillaud. The observations show unmistakably that very sensible changes of brightness have taken place in this nebula during the last twenty years.—Observations of $\beta$-Lyræ, made at the Observatory of Lyons, by M. M. Luizet.—On the variable star (D.M. + 12°·3557) of the Algol type, by M. Luizet.—On the methods of M. Loewy for the determination of latitudes, by MM. W. Ebert and J. Perchot.—The variations of the apparent horizon, by M. F. A. Forel. The possible error in the measurement of the position of the true horizon deduced from observation of the apparent horizon, is greater when the air is calm than when it is in motion, and greater than when the air is warmer than the water than the reverse; hence the observations are best taken in the morning.—On the equations of Pfaff, by M. E. O. Lovett.—On certain differential equations, by M. Henri Dulac.—On the changes of state of iron and steel, by M. H. Le Chatelier.—On the electric deformations of solid isotropic dielectrics, by M. Paul Sacerdote.—On the spectra of oscillating discharges, by M. G. A. Hemsalech.—With the oscillating discharges, a particular value for the self-induction of the circuit can be made to give a spectrum almost totally free from air lines, and showing very clearly the characteristic rays of the metals forming the electrodes.—On the isomeric states of chromium acetate: biacid abnormal violet acetate and a green abnormal monoacetate, by M. A. Recoura.—Action of magnesium upon saline solutions, by M. Georges Lemoine. Concentrated solutions of magnesium chloride rapidly disengage hydrogen when treated with magnesium powder, magnesia being simultaneously formed.—On the dissociation of the hexammoniacal cadmium chloride, by MM. W. R. Lang and A. Rigaut.—On the dissociation of mercurdiammonium iodide, by M. Maurice François. The compound of mercuric iodide and ammonia behaves similarly to the ammoniacal silver chlorides, the dissociation pressures showing that an intermediate compound $3HgI_2.4NH_3$ exists.—Action of sodammonium and potassammonium upon selenium, by M. C. Hugot.—On some acetonylacetonates, by MM. G. Urbain and A. Debierne. In the present paper details are given of the iron, manganese, cobalt, chromium, and aluminium compounds.—Action of mineral substances and organic acids upon the variations of resistance and modifications of the system, by MM. Charrin, Guillemonat, and Levaditi.—Immunity and specificity. Remarks on the preceding note, by M. Ch. Bouchard.—On the gluten and nitrogenous material of flour, by M. Balland. As flour grows older, the gluten appears to undergo a change, as it loses its coagulating properties, and is carried away in increasing quantity by washing with water.—Estimation of carbon dioxide at the summit of Mt. Blanc, by M. Maurice de Thierry. Details of estimations of ozone and carbonic acids carried out at Chamonix and Grand Mulets in August and September 1898.

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THURSDAY, AUGUST 17, 1899.

## ENZYMES.

*The Soluble Ferments and Fermentation.* By J. Reynolds Green, Sc.D., F.R.S. Pp. xiv + 480. (Cambridge University Press, 1899.)

PROBABLY no subject in the whole of the vast domain of biology exceeds this in interest, and certainly none transcends it in the importance of its bearings on the doings of the human race. The bread and cheese we eat, the beer and wine we drink, are entirely dependent on these ferments for their preparation; and the same is true of the processes of digestion which render their products assimilable into the plant or animal economy.

Then, have not Pasteur and men who have followed him made clear that the principle of fermentation lies at the root of an enormous class of diseases; aye, and demonstrated the truth of the doctrine by that most cogent of all arguments—experimental production of the disease from the use of the agents, and cure or prevention of it by the employment of the antidotes and therapeutic measures suggested by the scientific inquiry?

The making of jams, the tinning of preserved meats and fruits, the curing of hides and tanning of leather, and a hundred other branches of industry owe their successful pursuit to the intelligent application of the teachings of science; so clearly is this being recognised now, that it is becoming customary to speak of "fermentation industries" as a class. For it must no longer be supposed that brewing is the only fermentation industry; modern discovery in connection with dyeing, the curing of tobacco, the retting of flax, and many departments of agriculture show the necessity of extending the idea. Dr. Green's aim has been to collect all that is known of the study of those remarkable and curious bodies (Enzymes) which can be extracted from the protoplasm of living cells, can be precipitated mechanically from the solutions, and preserved as dry, impalpable powders, and still retain more or less unimpaired their astonishing powers of again bringing about decompositions of sugar, fats, proteids and other organic substances in solutions just as they could in the cell itself or in the waters outside the cell.

These powers are astonishing, because they are manifested so extensively by almost unweighably small quantities of the enzyme, and because they are exerted so smoothly and with such apparent ease and economy on bodies which we know to be very stable, and which can be artificially decomposed in similar ways only by the application of very energetic processes and very wastefully.

For it would seem that the study of fermentation is now the study of enzymes. Even the one sharply contrasted case—alcoholic fermentation—which Pasteur's classical labours appeared to place in a category apart from those of the enzymes, has come into line with the rest since Buchner's discovery that an enzyme-like body can be extracted from the cells of the yeast-plant, and can split up sugar into alcohol and carbon dioxide outside the living cell.

Very few authors have attempted the collection of the huge and ever-increasing mass of information scattered through the various journals devoted to special researches on fermentations, and the student had long been dependent on the now antiquated books of Schutzenberger and Naegeli for his summary of general views on the subject, until, in 1893, the extremely interesting but meagre brochure of Bourquelot came out to tantalise him with its disappointing sketch of recent progress. Now we can claim, from the hands of an English botanist, a comprehensive survey, which, whatever its few faults in detail, covers the enormous area admirably, and brings out the salient points and recent discoveries in a very satisfactory manner.

Until a few years ago, it was generally accepted that Pasteur's doctrine—fermentation is the result of life without oxygen—formed the corner-stone of the whole subject. The gradual recognition of the important parts played by the "soluble ferments," or *enzymes*, which, though their discovery dates from 1814, 1823, 1831, were not much studied before 1870, led to the further view that two categories of fermentation-processes must be distinguished, and the attempt was made by Naegeli and Sachs to uphold the idea that soluble or "unorganised" ferments (enzymes) act differently from "organised" or living ferments—*e.g.* bacteria, yeast-cells, &c.

Apart from other discrepancies, the fact that fermentations occur universally in higher plants and animals, as well as in lower organisms, rendered this view untenable, until the startling discovery by Buchner, in 1897, that a something of the nature of an enzyme can be extracted in water from the yeast-cell, which—outside the yeast-cell and quite independent of it—converts sugar into carbon dioxide and alcohol, may be said to have removed its last prop.

Although Lafar, in his remarkably able summary of the ferment-activity of the lower organisms, restricts the definition of fermentation to "transformations of matter . . . exclusively by the vital action of ferments," understanding by the latter word the living cells themselves, it is evident that we are here confronted with an entirely different definition of fermentation. Having abandoned successively the views that it is a phenomenon of life without oxygen, that it is confined to the protoplasmic activity of lower organisms, that there are two different categories of ferments—organised and unorganised, we are now threatened once more with the generalisation that fermentation is a purely chemical phenomenon due to the peculiar molecular activity of certain bodies formed, it is true, by protoplasm, but acting independently of it: a generalisation supported by Fischer's work on the constitution of the sugars, which he regards as so built up that an enzyme can only attack any particular sugar the molecular symmetry of which is related to its own, much as the wards of a lock can be overcome only by a key with a particular pattern.

Dr. Green gives us a very exhaustive account of the many various enzymes now known, classifying them under the following heads.

(1) Those which transform insoluble carbohydrates, producing soluble sugars—*e.g. Diastase* in germinating seeds and other plant-organs, which attacks starch;



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*Inulase*, which decomposes inulin ; *Cytase*, which hydrolyses cellulose.

(2) Those which transform more complex sugars into simpler compounds of the same class—*e.g.* *Invertase*, which attacks cane-sugar ; *Glucase*, which splits up maltose, and others.

(3) Those which break up glucosides into some sugar and an aromatic body—*e.g.* *Emulsin*, which decomposes the amygdalin of almonds into sugar and prussic acid ; *Myrosin*, which breaks up the sinigrin of mustard into a sugar and the pungent substance so well known.

(4) Proteolytic enzymes, such as *Pepsin* and *Trypsin*, which decompose insoluble and indigestible proteids into soluble and digestible peptones and other bodies, and play so important a part in digestive processes generally.

(5) The clotting enzymes which bring about coagulations—*e.g.* *Rennet*, so important in converting milk into cheese ; *Thrombase*, the enzyme concerned in the coagulation of blood ; *Pectase*, the chief agent in forming vegetable jellies.

(6) The *Lipases*, concerned in decomposing oils and fats.

(7) The *Oxydases*, a curious class of enzymes recently shown to be active in carrying oxygen and bringing about the oxidation of certain vegetable juices—*e.g.* *Laccase*, concerned in the formation of lacquer varnish.

(8) A number of enzymes as yet unclassified—*e.g.* *Urease*, which induces the formation of ammonium carbonate from urea, and the newly discovered "zymase" of Buchner—the alcohol producing enzyme.

It is, of course, impossible in a review to go far into particulars concerning these numerous forms, of which, moreover, there are many varieties. On reading Dr. Green's admirable and exhaustive account of them, the student will be struck with the prominent position which the study of plants occupies in the elucidation of the properties of enzymes. It has been far too fashionable in this country to regard enzymes and the study of fermentation as if they were in some way specially accredited to the domain of the chemist, whereas inasmuch as any such specialisation can be insisted upon, the study is far more within the domain of the botanist and the physiologist, a fact very clearly brought out in this book ; as are also many of the important bearings of the study on the numerous applications of botanical science in the arts.

Secondly, it is worth remarking, in full view of the industrious and valuable work done by able continental botanists and physiologists, how conspicuous are the researches of English investigators in this department of science during the last few years, denoting a phase of activity on the part of our physiologists and botanists which promises well in the future. The author has collected a long list of authorities, and since he has made the study of fermentations peculiarly his own for some years, we may accept the literature as practically complete. At the same time, in view of the remarks on p. 75, we should have expected some quotation of Mr. Parkin's recent and important paper on the inulins in monocotyledons.

In view of the modernity of the study of enzymes, we can hardly be surprised at the lack of any complete deductive explanation of their action, though one of the most interesting sections of the book is that discussing the various hypotheses raised. Our ignorance of the constitution of enzymes no doubt stands at the bottom of this, and it is not at present clear what is meant by a soluble enzyme or by solution. But the fatal blocks to progress in the study of their constitution so far have been their instability during separation, and the uncertainty as to their purity ; consequently the analyses so far attempted cannot be relied on, and we do not even know of any enzyme that it is proteid in nature. All we can be sure of is that a given watery extract washes out from living protoplasm a something—which we term an enzyme—which is capable of converting enormous masses of some other body—*e.g.* sugar—and can itself be mechanically precipitated, re-dissolved and so on. This precipitate may even be dried and retain its specific powers on re-solution. Whether the precipitate consists principally of the enzyme itself or of some body or bodies to which it is attached, is an unsolved question.

But when active and in solution, it is significant that the properties of an enzyme can be destroyed in a few moments by raising the temperature beyond a (relatively low) maximum, and that the activity rises and falls with a scale of temperature between the limits ; on the other hand, it differs from a living organism in being capable of exerting its specific power in presence of an antiseptic.

In the discussion regarding fermentation as a chemical process, these facts should not be overlooked, and it is as true to-day as it was in Pasteur's time, that you cannot have fermentation without life.

No matter how "dead" an enzyme may be ; no matter whether its remarkable energy consists in surface-actions or in vibrations propagated through the solution, in temporary chemical unions and disunions or in electrical hydrolysis ; and no matter what its chemical analyses may imply as to its proteid nature—the fact must be maintained that enzymes are built up by living protoplasm, and normally exert their best actions in connection with the living cell. In many respects, indeed, they suggest essential bits of the protoplasm, and in many ways remind us that we have not yet done with the physiological or "vital" theory of fermentation, and this will, we think, strike most readers, though perhaps Dr. Green's summing up inclines more to the view that fermentation is a purely chemical process. Not the least important prop to the chemical theory of enzyme-action is furnished by Croft Hill's recent work on the action of maltase or glucase on malt-sugar, and his remarkable discovery that a reversal of the enzyme-action may occur, reminding us of the reversals occurring in certain chemical processes.

Here, however, we must stop. It is not necessary to recommend the perusal of the book to all interested in the subject, since it is indispensable to them, and we will merely conclude by congratulating the Cambridge Press on having added to their admirable series of Natural Science Manuals an eminently successful work on so important and difficult a theme, and the author on having written a treatise cleverly conceived, indus-

triously and ably worked out, and, on the whole, well written. At the same time, it should be pointed out that such a work was especially in need of a good and exhaustive index, and that it is a pity the author did not compile one himself.

## CALCULATION BY ABACUS.

*Traité de Nomographie.* Par Maurice d'Ocagne. Pp. xiv + 480. (Paris: Gauthier-Villars, 1899.)

THIS is a book which ought to make even the ordinary reader appreciate the perennial freshness of mathematics. The method of "Nomography" (X3 of the international catalogue), recent as it is in its more important developments, is based upon a very simple idea which has long been familiar—that of the indexed scale. The ever-recurring problem of applied mathematics is to calculate an unknown numerical quantity from its relation to other quantities that are known. The simplest case is when two quantities $x, y$ are connected by a relation $f(x, y) = 0$ or $y = \phi(x)$. For practical purposes it is convenient to have a permanent record of a large number of corresponding values of $x$ and $y$ so that for any given value of $x$ the approximate value of $y$ may be at once found or obtained by simple interpolation. Three methods are available: the first is that of a numerical table, such as a table of logarithms; the second that of the graph, for instance the curve $f(x, y) = 0$ or $y = \phi(x)$ referred to rectangular coordinates; the third is that of the indexed scale, that is to say a straight line or curve at different points of which the corresponding values of $x$ and $y$ are shown in figures. A familiar example is given by a thermometer with Centigrade and Fahrenheit readings, or by a measuring tape with centimetres marked along one edge and inches along the other.

In this very simple case the advantage of the indexed scale is not very obvious; even here, however, the method combines much of the vividness of the graph with a considerable saving of space. It is when three or more variables are connected by a relation that the great value of the scale method becomes apparent. Suppose, for instance, we have a relation

$$F\{\phi(x), \chi(y), \psi(z), \omega(t)\} = 0$$

where $x$, $y$, $z$, $t$ are the variables and F, $\phi$, $\chi$, $\psi$, $\omega$ are known functions. The essence of the nomographic function consists in first plotting off in a suitable way indexed scales of $\phi(x)$, $\chi(y)$, $\psi(z)$, $\omega(t)$, and then employing a linkage or similar mechanism to associate four corresponding values, $x'$ $y'$, $z'$, $t'$. In the case of two variables $x, y$ the "linkage" consists merely in the juxtaposition of the scales; when a proportion sum is done with a slide-rule, the scales are moved relatively to each other; in most of M. d'Ocagne's illustrations, involving several variables, the scales are either superposed in a two-dimensional grating or a movable linkage is used consisting of a transparent sheet with lines of reference ruled upon it, or a combination of both devices is employed.

Of course a method so elastic leaves ample room for ingenuity in constructing an "abacus," as M. d'Ocagne calls it, suited to any particular problem. The author gives an abundant variety of illustrations, many of great practical importance to the physicist and engineer: it is by studying these, and actually taking readings for himself, that the reader will succeed in appreciating the value of the method. For of this, as of other graphical methods, it may be said that merely reading it up, or understanding its principles in a general way, is of little use as compared with a thorough working knowledge of its application.

At the same time, M. d'Ocagne has done really good service in devoting his final chapter to the general theory. This has, in its way, the same kind of special value as Reuleaux's "Kinematics of Machinery" in relation to the ordinary treatises on mechanism. For in this chapter we have a clear conspectus of the general principles which underlie the construction of *any* abacus; and, what is still more remarkable, all possible varieties of abacus are classified into perfectly definite types which can be expressed by a simple abstract notation. Oddly enough, the enumeration of the different types leads to a difficult problem in the partition of numbers, happily solved by Major MacMahon.

It is not impossible that the human race may ultimately set off against the ravages of warfare the indirect stimulus which it has given to mathematics; nomography, at any rate, has been developed in great measure to meet the demands of civil and military engineering. M. d'Ocagne's numerous bibliographical notes will enable his readers to follow in detail, if they wish, the history of the subject. Pure and applied mathematicians alike will be grateful to him for a work so full of novelty and interest; while its subject-matter, as well as its clearness and simplicity, ought to make it eminently acceptable to the engineer.

G. B. M.

## OUR BOOK SHELF.

*Die Spiele der Menschen.* By Karl Groos. Pp. vi + 538. (Jena: G. Fischer, 1899.)

PROF. GROOS will add by the present volume to the reputation he has already earned by his well-known work on the "Games of Animals." A really comprehensive account, at once sympathetic and intelligent, of the games of both children and adults has long been a desideratum with the psychologist as well as with the anthropologist, and Prof. Groos's new work goes very far indeed towards permanently supplying the want. As is only right and proper, by far the larger part of the book is given up to an exhaustive description of the facts as far as they are known; the "Theory of Play" enunciated in the second part of the treatise can thus be judged by the reader upon a sufficiently wide basis of empirical information. The range and the accuracy of Prof. Groos's knowledge are alike surprising; not only is he a mine of information about the amusements of his own country, but he appears, for instance, as much at home in the English nursery and playground as though he had been brought up amongst us. Almost the only signs of imperfect knowledge of English games to be detected in the whole book are the author's ascription of "Hare and Hounds," in its familiar form, exclusively to America, and his apparent ignorance of the continued vitality of "Hunt the Slipper." As a psychologist Prof. Groos is distinguished by a singular subtlety of discrimination; his account, for instance, of the various elements which enter into the gambler's enjoyment of high play, or, again,

of the combination of "the pleasure of intense stimulus" and the "pleasure of conflict" in our enjoyment of a tragedy, are models of delicate æsthetic analysis. The author's attitude towards the various current theories of "play" is eminently judicious. As he well points out, both the "surplus activity" theory and the "recreation" theory are one-sided, the former doing less than justice to the pastimes of adults, the latter to those of children. His own view that play must be regarded by the biologist primarily as the great educator and perfecter of imperfect instincts has been most nearly approached by Prof. Baldwin. Prof. Groos's treatment of the sociological aspects of "play," both as the child's earliest form of experimentation and as the earliest school of obedience to authority, should prove useful to students of ethics as well as to professed sociologists. The admirable literary style of the book, no less than the interest of its contents, should recommend it to all persons of general culture who care for anthropological studies. A. E. T.

*Physique et Chimie Viticoles.* By A. de Saporta. Pp. iv + 300. (Paris: G. Carré and C. Naud, 1899.)

IN the preface to this book, contributed by M. P. P. Dehérain, the immense importance of the vine culture to France is pointed out, the wine from the department of Hérault alone having in 1897 a value of 212,000,000 francs. The questions of suitability of soil, of manures, of the remedies against the many diseases of the vine, of fermentation, and preservation of wine all depend largely upon simple chemical and physical considerations; hence arises the necessity for such a work as the present, dealing with the physics and chemistry of vine culture and wine production. Of the eight chapters composing the book, the first two are preliminary, giving a very brief outline of the atomic theory and the measuring instruments used in the laboratory. The third chapter deals with the soil, especial attention being directed to the use of various insecticides, and to the causes of vine disease generally residing in the soil. In the third chapter, on account of the importance of the estimation of calcium carbonate in the soil, numerous calcimeters are described, some of considerable and apparently unnecessary complexity, as, for example, the self-registering calcimeter of Houdaille. The description of the properties of manures is lucid, and their analysis is treated in a simple manner. Chapter vi., dealing with the remedies for vine diseases, is, on account of the evident practical knowledge of the author, the most valuable portion of the book. The number of remedies that have been invoked to combat mildew, black rot, chlorosis, phylloxera, and other vine diseases, is so great as to render their classification and intelligent use difficult. Especial attention is here directed to the use of carbon bisulphide, ferrous sulphate, sulphur, copper sulphate and acetate, and mercury salts, the last-named being emphatically condemned in spite of their undoubted efficacy in combating fungoid diseases. The concluding chapters deal briefly with the fermentation of the grape, analysis of the wine, and the diseases to which it is liable. The book will be of great practical service to vine growers.

*Cours Élémentaire de Zoologie.* Par Remy Perrier. Pp. 734. 697 illustrations. (Paris: Masson et Cie., 1899.)

THIS work contains a great deal in brief that is to be found in its predecessor, the author's "Éléments d'Anatomie Comparée," published in 1893. In some respects it may be said to be a "Grundriss" to that volume, but, in contradistinction to it, the Vertebrata are here treated on a greater equality with the Invertebrata, and the order of presentation is more rational and in accordance with precedent. For example, the Chætopod Worms are dealt with before the Arthropods, the inversion of this order being a notorious feature of the "Éléments." Chapter i. is devoted to broad principles and definitions, Chapter ii. to the elements of histology, and Chapter iii. to the classification of the metazoa—177 pp. in all. Tables of affinity and structural relationship are here and there given, and the 565 remaining pages of the work are devoted to a systematic consideration of each of the greater groups of animal forms in an ascending order, the Echinoderms, Rotifers, Polyzoa, and Brachiopods being taken after the Cœlenterates and before the Leeches and Worms. Some of the groups receive but scanty treatment, meagre and wholly insufficient, and throughout the work the author has conspicuously neglected the rendering clear the extremes of modification of the great groups, which we consider should be an indispensable feature of an elementary text-book on organic forms that shall do justice to our present knowledge. In dealing with such an assemblage as the Tunicata, where octoradiate, valved, stalked, and many other well-known forms occur, a great opportunity has in this way been lost, and the same may be said of the author's treatment of the Bryozoa.

The illustrations are for the most part good and clear; some of the new ones are admirable, and we congratulate the author upon such as his aortic arch series (p. 602), which are the most accurate and up to date of any text-book set yet published. They are sure to be popular and reproduced *ad nauseam.* But why that old nightmare the Cuvier's "Chimæra" (Fig. 589), a badly drawn Chimæra with a Callorhynchus tail! Surely the time has come when this and other persistent atrocities of our text-books, which have so long offended, should be condemned.

A really sound elementary treatise on zoology has long been a desideratum, and the present work is the outcome of a commendable attempt to supply the need. Though desperately thin in parts it is up to date in its leading themes, well arranged, and written in a good easy style, and it may be safely recommended as trustworthy so far as it goes.

## *LETTERS TO THE EDITOR.*

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### Thermometric Scales for Meteorological Use.

IN the course of some recent work on the meteorology of Ben Nevis, which involved extensive extracting and computing work, I have again had forcibly impressed on me the great advantage which Fahrenheit's thermometer has over that of Celsius for meteorological use, especially in temperate regions.

In chemistry and physics the range of temperature covered is so great that Celsius' scale, which is now universally used, adequately meets every case. The size of the degree and the change of sign at the melting point of ice do not cause any inconvenience in the laboratory. It is otherwise in the meteorological observatory. There the range of temperature dealt with is very restricted, and the Celsius degree is too large, while the change of sign in the middle of the working part of the scale is simply intolerable. The latter peculiarity is the fruitful introducer of error into both the observations and the reductions, and besides it greatly increases the fatigue of both classes of work.

In view of the agitation to abolish the use of Fahrenheit's scale, and to replace it universally by that of Celsius, it may not be inopportune to direct attention to some of the advantages in securing accuracy and in relieving labour which Fahrenheit's scale offers over that of Celsius when used for meteorological purposes.

In tropical countries it matters little whether one scale or the other is used, except that the size of Fahrenheit's degree is much

the more convenient, as the first decimal place is always sufficient. But in Europe and in North America, where the greater number of meteorological observatories is situated, the temperature falls every year below the freezing point of water. In some localities it passes quickly through this point and remains constantly below, often far below it, returning again in the spring and passing as quickly through it again in the beginning of summer, to remain constantly above it until it drops away again in the fall of the year. In such places, where, however, the population affected is limited, the use of Celsius' scale is not open to very much objection. With the exception of a few days in the fall, and again in the spring of the year, the temperatures are either continuously positive or continuously negative; and during one-half of the year the observer reads his thermometer upwards, while during the other half of the year he reads it downwards. When he has got well into the one or the other half of the year, he will make no more errors than those that he is personally liable to under circumstances of no difficulty. But at and near the two dates when the temperature is falling or rising through that of melting ice the case is very different. If the rise or fall is rapid, his task is comparatively easy, and, after a few unavoidable mistakes, he has succeeded in inverting his habit of reading. But, in those parts of Europe and North America which carry nearly the whole of the population, the temperature in winter is frequently oscillating from one side to the other of the melting point of ice. If the observer is compelled to use a thermometer which he must read upwards when the temperature is on one side of that point, and downwards when it is on the other side, and if he may be called on to perform this fatiguing functional inversion several times in one day, it is certain that he will suffer from exhaustion, and that the observations will be affected with error.

Were there no other thermometric scale available but that of Celsius, we should simply have to put up with it, and endure the inconvenience of it; but, when we have another scale, one devised primarily for meteorological observations in the North of Europe, by a philosopher who constructed it with a single eye to its fitness for what it was to be called upon to measure, and when, in addition, this scale is still exclusively used in a large proportion of the meteorological observatories of the world, it seems almost incredible that amongst reasonable people, be they scientific or non-scientific, there should be a powerful agitation to abolish the scale which was devised for its work, which excludes error in so far as it can be excluded, and to replace it by one which, besides other defects, introduces, in the nature of things and of men, *avoidable* errors, the elimination of which is the first preliminary of the scientific treatment of all observations in nature.

Every meteorologist in northern countries who makes use of the data which he collects knows that when his temperatures are expressed in Fahrenheit's degrees, he can discuss them at much less expense both of labour and of money for computing than when they are expressed in Celsius' degrees; yet such is the apprehension of even scientific men when brought face to face with the risk of being ruled "out of fashion," that meteorologists who use Fahrenheit's scale, though they fortunately do not give up its use, seem to be disabled from defending it.

What is this stupefying fashion, and can it not be made our friend?

Fahrenheit lived and died before the decimal cult or the worship of the number ten and its multiples came into vogue; but, whether in obedience to the prophetic instinct of great minds or not, it almost seems as if he had foreseen and was concerned to provide for the weaknesses of those that were to come after him. The reformers of weights and measures during the French revolution rejected every practical consideration, and chose the new fundamental unit, the metre, of the length that it is, because they believed it to be an exact decimal fraction one ten-millionth of the length of the meridian from the pole to the equator. Is it an accident that mercury, which was first used by Fahrenheit for filling thermometers, expands by almost exactly one ten-thousandth of its volume for one Fahrenheit's degree?

Again, how did Fahrenheit devise and develop his thermometric scale? A native of Danzig and living the first half of his life there, he considered that the greatest winter cold which he had experienced in that rigorous climate might, for all the purposes of human life, be accepted as the greatest cold which required to be taken into account. He found that this temperature could be reproduced by a certain mixture of snow and salt. As a higher limit of temperature which on similar grounds he held to be the highest that was humanly important, he took the temperature of the healthy human body, and he subdivided the interval into twenty-four degrees, of which eight, or one-third of the scale, were to be below the melting point of pure ice, and two-thirds or sixteen were to be above it. Fahrenheit very early adopted the melting temperature of pure ice for fixing a definite point on his thermometer, but he recognised no right in that temperature to be called by one numeral more than by another. The length of his degree was one-sixteenth of the thermometric distance between the temperature of melting ice and that of the human body, and the zero of his scale was eight of these degrees below the temperature of melting ice, and not, as is often thought, the temperature of a mixture of ice and common salt or sal-ammoniac. Fahrenheit, as has been said, was the first to use mercury for filling thermometers; and being a very skilful worker, he was able to make thermometers of considerable sensitiveness, on which his degrees occupied too great a length to be conveniently or accurately subdivided by the eye. To remedy this he divided the length of his degree by four, and the temperature from the greatest cold to the greatest heat which were of importance to human life came to be subdivided into 96 degrees.

Had he lived in the following century he would have been able to point out that on his scale the range of temperature within which human beings find continued existence possible is represented by the interval 0 to 100 degrees, and there can be little doubt that this would have secured its general adoption. Its preferential title to the name Centigrade is indisputable. Perhaps this may be an assistance to its rehabilitation as the thermometer of meteorology. J. Y. BUCHANAN.

Cambridge, August 4.

## On the Deduction of Increase-Rates from Physical and other Tables.

THE problem treated by Prof. Everett in your issue of July 20, p. 271, allows a somewhat simpler solution. Take the example given by Prof. Everett. To find the value of $\frac{dp}{d\theta}$ at the temperature 105°, we have only to consider the columns for $\Delta p$, $\Delta^3 p$, $\Delta^5 p$, &c. In each of these columns there are two numbers, one just above and one just below the horizontal line, corresponding to the value $\theta = 105°$. In the column for $\Delta p$, for instance, these two numbers are 408 and 470, in the column for $\Delta^3 p$ they are 5 and 8. If now $m_1$, $m_3$, $m_5$, &c., are the means of each of these two numbers, so that in this case $m_1 = 439$, $m_3 = 6.5$, we have:

$$\frac{hdp}{d\theta} = m_1 - \frac{m_3}{2.3} + \frac{m_5}{2.3.4.5} 2^2 - \frac{m_7}{2.3.4.5.6.7} 2^2 3^2 + \ldots$$

If $p$ be capable of being expressed in the form $A + B\theta + C\theta^2$ only the first term $m_1$ is required; if

$$p = A + B\theta + C\theta^2 + D\theta^3 + E\theta^4$$

only the first two terms $m_1 - \frac{m_3}{2.3}$ are required, and so forth. In these cases the solution is exact, whereas in general the method gives only approximations closer and closer the more terms are added.

The difference between my solution of the problem and Prof. Everett's is only formal. It may readily be seen that in Prof. Everett's notation

$$2m_1 = d_1 + u_1,\ 2m_3 = d_2 - u_2,\ 2m_5 = (d_3 + u_3) - (d_2 - u_2),$$

which makes his equations special cases of my expression for $\frac{hdp}{d\theta}$. The proof of my expression may be given by the calculus of finite differences. For simplicity let us write $x = \theta - 105°$, and let us develop the function $p$ in the form:

$$p = a_0 + a_1 x + \frac{a_2}{2} x(x-h) + \frac{a_3}{2.3}(x+h)x(x-h) + \ldots$$

General terms:

$$\frac{a_{2n}}{2.3.4\ldots 2n}(x+(n-1)h)\ldots x \ldots (x-nh)$$

$$+ \frac{a_{2n+1}}{2.3.4\ldots 2n+1}(x+nh)\ldots x \ldots (x-nh)$$

By the calculus of finite differences we obtain :

$$\frac{\Delta p}{h}=\frac{p(x+h)-p(x)}{h}=a_1+a_2x+\frac{a_3}{2}(x+h)x+\frac{a_4}{2.3}(x+h)x(x-h)+\ldots$$

and

$$\frac{\Delta^2 p}{h^2}=a_2+a_3(x+h)+\frac{a_4}{2}(x+h)x+\frac{a_5}{2.3}(x+2h)(x+h)x+\ \ldots$$

Therefore :

$$ha_1=\Delta p \text{ for } x=0 \text{ and } h^2a_2=\Delta^2 p \text{ for } x=-h$$

By proceeding in the same way we find $h^{2v}a_{2v}=\Delta^{2v}p$ for $x=-vh$ and $h^{2v+1}a_{2v+1}=\Delta^{2v+1}p$ for $x=-vh$.

The value of $\Delta^{2v}p$ for $x=-vh$ is the number in the column for $\Delta^{2v}p$, which stands in the horizontal line corresponding to the stated value of $\theta$ (105 in our case), while the value of $\Delta^{2v+1}p$ for $x=-vh$ is the number in the next column just below this line. The mean of this number and the one above it we have before denoted by $m_{2v+1}$ ; we now add the notation $m_{2v}$ for the value of $\Delta^{2v}p$ for $x=-vh$. As $m_{2v+2}$ is the difference of the two numbers, whose mean is $m_{2v+1}$, we can write $m_{2v+1}+\frac{1}{2}m_{2v+2}$ instead of the value of $\Delta^{2v+1}p$ for $x=-vh$.

We have therefore :

$$a_{2v}=m_{2v}h^{-2v}$$

and

$$a_{2v+1}=(m_{2v+1}+\tfrac{1}{2}m_{2v+2})h^{-2v}.$$

Substituting these values in the expression for $p$ we have :

$$p=a_0+(m_1+\tfrac{1}{2}m_2)\frac{x}{h}+\frac{m_2}{2}\frac{x(x-h)}{h^2}$$
$$+\frac{1}{2.3}(m_3+\tfrac{1}{2}m_4)\frac{(x+h)x(x-h)}{h^3}+\ \ldots$$

General terms :

$$\frac{1}{2.3\ \ldots\ 2v+1}(m_{2v+1}+\tfrac{1}{2}m_{2v+2})(x+vh)\ \ldots x \ldots\ (x-vh)h^{2v-1}$$
$$+\frac{1}{2.3\ \ldots\ 2v+2}m_{2v+2}(x+vh)\ \ldots\ x\ \ldots\ (x-vh)$$
$$(x-(v+1))h^{-2v-2}.$$

To find the value of $\frac{dp}{d\theta}$ we now need only differentiate according to $x$ and make $x$ equal zero.

Thus we obtain :

$$h\frac{dp}{d\theta}=(m_1+\tfrac{1}{2}m_2)-\frac{m_2}{2}-\frac{1}{2.3}(m_3+\tfrac{1}{2}m_4)+\frac{1}{2.3}\frac{m_4}{2}+\ \ldots$$

General terms :

$$\frac{(-1)^v}{2.3\ \ldots\ 2v+1}(m_{2v+1}+\tfrac{1}{2}m_{2v+2})2^2\,.\,3^2\ \ldots\ v^2$$
$$+\frac{(-1)^{v+1}}{2.3\ \ldots\ 2v+2}m_{2v+2}\,.\,(v+1)\,.\,2^2\,.\,3^2\ \ldots\ v^2;$$

or by contracting two consecutive terms :

$$h\frac{dp}{d\theta}=m_1-\frac{1}{2\,.\,3}m_3+\frac{1}{2\,.\,3\,.\,4\,.\,5}m_5\,.\,2^2-\ \ldots$$

The second differential coefficient is found in a similar way. It is only necessary to observe that the second differential coefficient of $(x+vh)\ \ldots\ x\ \ldots\ (x-vh)$ vanishes for $x=0$ and that of $(x+vh)\ \ldots\ x\ \ldots\ (x-(v+1)h)$ is equal to $2\,.\,(-1)^v\,.\,2^2\,.\,3^2\ \ldots\ v^2h^{-2v}$. Therefore we obtain

$$h^2\frac{d^2p}{d\theta^2}=m_2-\frac{2}{2\,.\,3\,.\,4}m_4+\frac{2}{2\,.\,3\,.\,4\,.\,5\,.\,6}\,.\,2^2\,.\,m_6-\ \ldots$$

General term :

$$\pm\frac{2}{2\,.\,3\,.\,4\ \ldots\ 2v+2}2^2\,.\,3^2\ \ldots\ v^2\,.\,m_{2v+2}.$$

Hannover, Technische Hochschule. C. RUNGE.

PROF. RUNGE'S proof is longer and more difficult than mine ; but his result is in simpler shape, and possesses the great merit of giving the successive approximations as the terms of a regular series. J. D. EVERETT.

22 Earl's Court Square, July 28.

## The So-called "Thunder"-storm.—Prevalence of Anticyclones.

IT must have occurred to others besides myself how very absurd it is to designate a meteorological phenomenon by the least important of its characteristics, viz. the noise it makes. We never speak of a hail-storm as a "rattle"-storm, or a shower of rain as a "patter"-storm ; why then should we call an electrical disturbance a "thunder"-storm ? Thunder, though no doubt terrifying to savages and children and old ladies (one or two of whom have, I believe, been killed by the fright of it), and though of some interest as an acoustic phenomenon, is absolutely the most trivial of the accompaniments of an electrical discharge.

It would seem hopeless to eradicate the childish term entirely from popular language, but surely in the scientific reports and forecasts issued by the Meteorological Office, and in scientific literature generally, the term "electric storm" (or disturbance) might replace "thunderstorm."

With regard to the late prevalence and persistence of anticyclonic conditions over the centre and south of our islands, I wish to suggest that it may be connected with the unusual extension southwards of the Polar ice-pack this summer. I saw it stated about a month ago that even Spitsbergen was then surrounded by ice, most of the fiords being quite inaccessible. When I was there in July 1896 we could only just see the blink of the pack in the north horizon.

Now, it is an ascertained and easily intelligible fact that areas of cold (water or ice) on the earth's surface have a tendency to cause the formation of areas of high pressure or dense air in the atmosphere above them. The result would be, not only a prevalence of anticyclones in high latitudes over the North Atlantic, but also the persistent extension of the northern edge of the great "Atlantic anticyclone" over the south and centre of England (attracted, as it were, by the high pressure in the north) ; so that cyclones which usually strike the south-west of Ireland or the coast of Cornwall have been "fended off" to the north of Scotland, with the result of heat and drought over England.

I only put this forward as a suggestion, and I should be glad if any of your Icelandic or Norwegian readers would supply details of the position of the Polar ice-pack, temperature of the sea in the North Atlantic, &c., for I have learnt to mistrust all statements appearing in those interesting, and often sensational, works of fiction—the daily papers. METEOR.

August 12.

## Scoring at Rifle Matches.

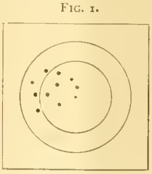
WHILE the Bisley meeting is still fresh in the memory of those interested in rifle shooting, it seems worth while to call attention to the rather unsatisfactory nature of the method of scoring now in general use.

What brings the matter into special prominence is the large number of "best possibles" always made in recent years.

With a satisfactory system of scoring such a phrase ought only to apply when every shot passes through the same hole in the centre of the bull's-eye.

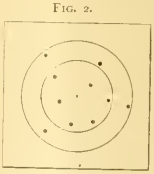
The present practice, however, gives the same number of marks to shooting of widely differing merit, and this must always be the case as long as the result is made to depend on the distance of each shot from the centre of the target, irrespective of the distance of the shots from one another (see Figs. 1 and 2).

FIG. 1.



Ordinary score 46.
By moment of inertia 24·5.

FIG. 2.



Ordinary score 46.
By moment of inertia 18.

The merit of any series of shots really depends on two elements, namely, the distance of the average direction of the whole series from the centre of the target and the compactness with which the individual shots are grouped about that direction.

The importance to be assigned to each of these elements may vary with the object for which the shooting is undertaken, but a knowledge of both is essential in estimating its quality.

If the object be to get all the shot as near the centre of the target as may be, the same importance should be attached to close grouping as to the mean direction, as will be shown further on.

Since any practical method of scoring must be rapid and easily understood by people who are not mathematical, it would probably be asking too much if it were proposed to treat each result in an accurate manner, simple though the required arithmetic is; but some modification of the accurate method could probably be made sufficiently simple for general use, which would give a much truer estimate of the goodness of the shooting than that now in use.

The accurate plan of estimating the value of any series of shots consists, in mathematical language, of finding the distance of the centre of gravity of the group from the centre of the target, and taking the radius of gyration of the group about its centre of gravity. The goodness of the shooting will then be measured by the reciprocal of the sum of the squares of these quantities, each multiplied by a constant, and it will presently be shown that if, as in an ordinary match, the object is to hit the centre of the target, these constants are equal.

A convenient way of finding the centre of gravity and radius of gyration is to have the target divided into 100 squares by eleven vertical and eleven horizontal lines (see Fig. 4), the position of the shot being recorded by naming the square through which it passes; (for instance, a shot in the fourth vertical row and fifth horizontal row would be recorded as 4·5).

If we call the number of the vertical row $x$, and the number of the horizontal row $y$, very simple algebra will prove—in fact, it is obvious—that for a series of $n$ shots the coordinates $(h \,.\, k)$ of square containing the centre of gravity of the shots will be

$$h = \Sigma x/n \quad k = \Sigma y/n,$$

where $\Sigma x$ denotes the sum of all the $x$'s, and $\Sigma y$ denotes the sum of all the $y$'s.

Since the score does not record the position of an individual shot with greater accuracy than the width of a single square this is equivalent to the assumption that each shot passes through the centre of the square it hits, and that the origin of the coordinates is in the centre of the square at 0 (off the target) (see Fig. 4).

Thus the coordinates of the centre of the target will be

$$x = 5{\cdot}5 \quad y = 5{\cdot}5,$$

and the distance of the centre of gravity from the centre of the target is

$$R = \sqrt{(\Sigma x/n - 5{\cdot}5)^2 + (\Sigma y/n - 5{\cdot}5)^2}.$$

The radius of gyration of the group about an axis normal to the plane of the target, and passing through the centre of gravity is

$$\rho = \sqrt{\Sigma x^2/n - h^2 + \Sigma y^2/n - k^2}.$$

To examine the relative importance of the closeness of the shots to one another and the distance of their mean from the centre of gravity, consider the effect of slightly varying each of the quantities R and $\rho$.

The question to be answered is: "If of two groups one is represented by R and $\rho$, and the other by $R + dR$ and $\rho - d\rho$, which gives evidence of the best shooting?"

In Fig. 3 let C be the centre of the target, and G the centre of gravity of the group, and P Q R a circle described with radius $\rho$ about G, so that $CG = R$, $GP = \rho$; then if $CGP = \theta$, the distance $(r)$ of P from C is

$$r = \sqrt{R^2 - 2R\rho\cos\theta + \rho^2},$$

differentiating with respect to R and $\rho$, we have

$$\frac{dr}{dR} \Big/ \frac{dr}{d\rho} = -\frac{\rho - R\cos\theta}{R - \rho\cos\theta};$$

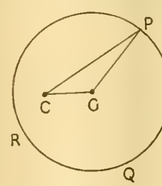



FIG. 3.

and integrating this with respect to $\theta$ from $\pi$ to 0 we have for the relative mean values of $dr$, caused respectively by alterations of $dR$ and $-d\rho$ in the values of R and $\rho$,

$$\left\{ \int_0^\pi \frac{dr}{dR} \Big/ \int_0^\pi \frac{dr}{d\rho} \right\} d\theta = \frac{\rho}{R}.$$

If the two groups are equally good, the mean value of $dR$ must be equal to minus the mean value of $d\rho$.

This leads to a simple relation between R and $\rho$, viz. $R^2 + \rho^2$ = constant. Thus any group of shots for which the sum of the squares of the mean distance of the group from the centre and its radius of gyration is constant is equally good.

This may be stated more concisely by saying that when the object is to hit the centre of the target, the merit of any series of shots is inversely proportional to its moment of inertia of the group about the centre of the target.

If for convenience it is decided to make the score 100 when the moment is unity, the worth of any given series will be represented by

$$\frac{100}{R^2 + \rho^2}.$$

I give below an actual target with the results analysed in the way described.

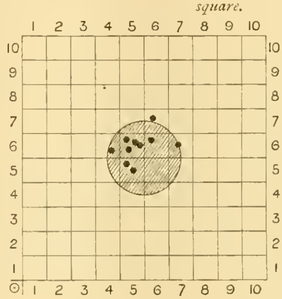
If a slide rule is used, the arithmetic takes about five minutes.

I do not for a moment suppose that such an analysis would be practicable at ordinary rifle matches, but it does seem possible that coordinate targets might become popular, and some simple way devised of using the more precise information they would afford.

As far as finding the moment of inertia of the group about the centre of the target is concerned, this might be done more simply by the use of polar coordinates, only the mean square of the distance from the centre being wanted for that purpose; but the Cartesian coordinates are more convenient when the closeness of the grouping has to be considered.

EXAMPLE.

*Coordinate Target. Ten shots at* 100 *yards. Target* 10 *inches square.*




| Shot | Score X | Score Y |
|---|---|---|
| 1 | 5 | 6 |
| 2 | 4 | 6 |
| 3 | 5 | 5 |
| 4 | 5 | 6 |
| 5 | 6 | 7 |
| 6 | 7 | 6 |
| 7 | 5 | 6 |
| 8 | 6 | 6 |
| 9 | 5 | 6 |
| 10 | 5 | 5 |

FIG. 4.

To analyse the score it is convenient to arrange the results in the following form; $p$ and $q$ being the number of shots on each vertical and horizontal row.

| $x$ | $p$ | $px$ | $y$ | $q$ | $qy$ | $px^2$ | $qy^2$ |
|---|---|---|---|---|---|---|---|
| 1 | — | — | 1 | — | — | — | — |
| 2 | — | — | 2 | — | — | — | — |
| 3 | — | — | 3 | — | — | — | — |
| 4 | 1 | 4 | 4 | — | — | 16 | — |
| 5 | 6 | 30 | 5 | 2 | 10 | 150 | 50 |
| 6 | 2 | 12 | 6 | 7 | 42 | 72 | 252 |
| 7 | 1 | 7 | 7 | 1 | 7 | 49 | 49 |
| 8 | — | — | 8 | — | — | — | — |
| 9 | — | — | 9 | — | — | — | — |
| 10 | — | — | 10 | — | — | — | — |
| | | $\frac{\Sigma x}{n}$ 5·3 | | | $\frac{\Sigma y}{n}$ 5·9 | $\frac{\Sigma x^2}{n}$ 28·7 | $\frac{\Sigma y^2}{n}$ 35·1 |
| | | $\frac{\Sigma x}{n} - h =$ 5·5 | | | $\frac{\Sigma y}{n} - k =$ 5·5 | $\left(\frac{\Sigma x}{n}\right)^2$ 28·1 | $\left(\frac{\Sigma y}{n}\right)^2$ 34·7 |
| | | −·2 | | | ·4 | ·6 | ·4 |
| | | | | | | | .6 |
| | | $R^2 = (\cdot 2)^2 + (\cdot 4)^2 = \cdot 2$ | | | | | $\rho^2 =$ 1·0 |

This counts $\frac{100}{1 + 2{\cdot}2}$ or 84.

A. MALLOCK.

## ON SPECTRUM SERIES.[1]

WE have now, I trust, obtained a general idea of inorganic evolution so far as stratigraphic geology is concerned. You may remember that I pointed out that the evidence for organic evolution not only depended upon the various vegetable and animal forms which had been found in the various strata of the earth's crust from the pre-Laurentian up to the Recent times, but that the science of embryology had also been brought into play, and that a succession of forms in the individual was there to attest the general line of descent. To-night we have to deal with the spectroscope and the motions of the smallest units of inorganic matter which we can get at, and to compare the results obtained in this way with some of those that the biologist has arrived at by means of the microscopic examination of the smallest unit forms that he can observe. From the spectrum point of view, this inquiry is included in the word "series." In the study of series of lines in different spectra, we are on the same ground plan as the biologist is when he is studying what he calls cytology, or the laws of cells.

To explain what is meant by "series" I will refer to one or two photographs of what are termed fluted spectra. You will observe that such a spectrum is perfectly rhythmic from end to end. The whole of a fluting may be regarded as a unit; it is generally strongest towards the right or the red end of the spectrum, its elements gradually becoming dimmer as we approach the violet end. But a fluting is generally more than this; it is built up of subsidiary flutings. Each of the subdivisions of it is in itself an almost exact representation in the small of what the whole thing is in the great; so that we have the conceptions of a simple fluting and a compound fluting. The compound flutings are well represented in the flu tings of carbon. It is by means of such photographs that t he existence of carbon in the sun has been determined. Each of the finer lines in one of the first elements of the compound fluting has a dark line corresponding with it among the Fraunhofer lines. In the case of the spectrum of nitrogen we get the same exquisite rhythm, the same intensification of the series of lines towards the red, and the same division of some of the larger flutings into smaller divisions; so that, as I said before, we have to consider flutings really as compound and not as simple phenomena. When we leave these flutings and study an ordinary line spectrum, in a great many cases all rhythm seems to have disappeared. There is apparently no law and no order. Let us take the lines seen when we expose the gases obtained from the mineral cleveite to the action of an electric current.[1] We observe that all rhythm has gone, and there seems to be a very irregular distribution; but when we come to sort those lines out into series, we find that there is just the same exquisite order that we get in the case of the flutings. You notice in the photograph all the lines higgledy-piggledy, the next photograph will show that they have all been resolved into two sets of three series which very much resemble those that we saw before; that is to say, they gradually get nearer together towards the violet, and they all get stronger towards the red. We have then two constituents of the cleveite gases, asterium and helium, and we find that their irregular line spectra when analysed into these series are translated into a wonderful order. I suggested many years ago that the lines in the ordinary line spectrum of a substance may really be remnants of compound flutings, and such inquiries as those that I have to refer to to-night really seem to justify that suggestion. Very well, then, we arrive at the fact that the term "series" is one employed to related lines. It is impossible to suppose that these wonderful rhythmic series of lines are not related in some way to each other, and that being so we have to study their wave-lengths, that is, their positions in the case of any one element; and not only so, but to see if any relation exists between the lines of different elements.

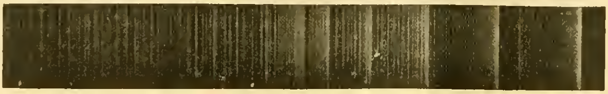


FIG. 1.—Compound flutings of carbon.

FIG. 2.—Simple flutings of nitrogen.

The history of this quite modern inquiry is not very long, but short as it is I only propose to refer to it in the briefest possible manner.

The first attempt to discover regularities in the lines of spectra was made by Lecoq de Boisbaudran,[2] who investigated the spectrum of nitrogen. The conclusions he arrived at suggested that the luminiferous vibrations of the molecules could be compared with the laws of sound, but as these were not based on wave-length determinations of sufficient accuracy, and also were not confirmed by Thalén, no great weight could be attached to the result.

Stoney,[3] who followed up these investigations, was more successful; he showed that the hydrogen lines C, F, and *h* were connected by the relationship 20 : 27 : 32.

Several other workers—Reynolds, Soret, &c.—took the subject up, but it was left for the more thorough work of Schuster[4] to show that this theory could no

[1] A Lecture to Working Men delivered at the Museum of Practical Geology, on May 1, by Prof. Sir Norman Lockyer, K.C.B., F.R.S.

[1] It has always been customary with me in reproducing spectra in the form of illustrations to show the red end of the spectrum on the right hand side and the violet end on the left. As most of the workers on "series" have adopted the opposite way, I propose *in this lecture* to depart from my usual custom and place the red in series spectra on the left, so that all the series illustrations may be comparable *inter se*.

[2] *Comptes rendus* (1869), 69, 694.

[3] *Phil. Mag.*, 1871 [4], 41, 291.

[4] Brit. Assoc. Report, 1880; *Proc. R.S.* (1881), 31, 337.

longer be considered as expressing the law connecting the mutual relationships between the wave-lengths of lines in a spectrum.

Liveing and Dewar[1] next called attention to the fact that the distance between two consecutive lines of these groupings decreases with diminishing wave-lengths, so that eventually the lines asymptotically approach a limit. "Harmonic" was the term they used to express such a series of similar groups of lines.

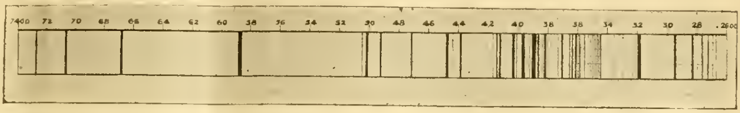


FIG. 3.—Spectrum of the Cleveite gases.

It was, however, the work of Balmer which gave the subject the impetus by which it has of late years made great progress.

Balmer[2] published a formula by which the positions of the hydrogen lines could be calculated with wonderful accuracy. The formula is as follows :—

$$\lambda = A \frac{n^2}{n^2 - 4},$$

in which $\lambda$ is the wave-length in vacuo of the line to be calculated, A a constant common for all the lines, and $n$ one of a series of numbers from 3 to 15.

The constant A, according to Cornu's measurements, is 3645·42 Ångstrom units, or, using Ames' more correct value, 3647·20 Ångstrom units.

Simultaneously with Balmer's discovery, Cornu[3] pointed out that the lines of aluminium and thallium, which are readily reversible, bear a definite relation to those of hydrogen, while at a later date Deslandres[4] published a formula from which could be calculated the wave-lengths of the lines composing the bands of numerous elements.

The above brief history brings us down to the year 1887, in which Kayser and Runge[5] began their series of minute investigations dealing with a great number of elements. It was also about this time that Rydberg[6] commenced to take up the subject.

I will state generally the ground over which their work has extended. They have attacked the question mathematically from different standpoints. In the following table I give the formula employed by Kayser and Runge, and that employed by Rydberg.

*Formulae for Calculating Series.*

| Kayser and Runge | Rydberg. |
|---|---|
| $\frac{1}{\lambda} = A + Bn^{-2} + Cn^{-4}$ | $n = n_0 - \frac{N_0}{(m+\mu)^2}$ |
| where | where |
| $\lambda$ = wave-length | $n$ = wave frequency |
| (or $\frac{1}{\lambda}$ = wave frequency) | $m = 1, 2, 3, \ldots$ |
| $n = 3, 4, 5, \ldots$ | $N_0 = 109721·6$ (a constant applicable to all series of every element) |
| A, B, C = constants calculated for each series. | $n_0$, $\mu$ = characteristic constants varying with each series. |
| The constants for the principal series are different from those used in the subordinate series. | In the above formula, when $m = \infty$, $n = n_0$; or $n_0$ is the limit which the number of waves $n$ approaches when $m$ is infinite. |
| For sub-series of Na, K, Rb, Cs, Cu, Ag, Al, In, and Tl, the constants B and C are identical. For all series the constant B does not vary by more than 22 per cent. This constant B corresponds to Rydberg's $N_0$. | The value of $N_0$ is assumed by Rydberg to be constant, as it varies only slightly, and this variation may be due to uncertain data. |

You will see that they are not by any means identical, but both deal with wave frequency, that is to say, the number of waves in a given unit of length. Then they employ a certain sign, $n$, to represent the successive integers which have to be used to define certain of their terms, and in addition to this we get certain constants which are calculated for each series. The most interesting consideration from this point of view is that Rydberg found that there was one constant which he could use in order to search for the series of lines in the spectra of all the chemical elements with which he worked. There was no common constant similar

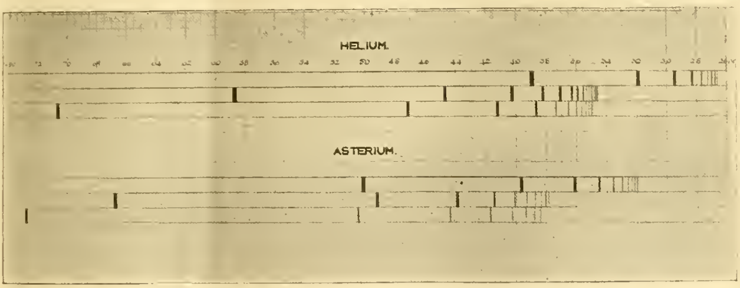



FIG. 4.—Spectrum of the Cleveite gases sorted out into six regular series.

1 *Phil. Trans.*, 1883, p. 213, and previously.
2 *Wied. Ann* (1885), 25, 80.
3 *Comptes rendus* (1885), 100, 1181.
4 *Ibid.* (1886), 103, 375 ; (1887), 104, 972.
5 "Ueber die Spectren der Elemente" (*Abhandlungen d. K. Akad. Berlin*, 1880, 1889, 1890, 1891, 1892, 1893.
6 *Svenska Vetenskap. Akad. Handlingar*, Stockholm (1890), 23, No. 11 ; *Wied. Annalen* (1893), 50, 629 ; (1894), 52, 119.

to this used by Kayser and Runge, but they found that some of their constants varied little from element to element. In that way they not only obtained the first term of a series, but the whole series throughout the entire length of the spectrum, and where observations had been made in the case of the different elements they could of course check their calculations by the actual observations so made, and see how the theory seemed to be justified as the work was extended. The first line in a series must be considered to be comparable to a fundamental note in music. It represents really the longest light wave in the same way that the fundamental note in music represents the longest sound wave. Both series of results, obtained in the way I have described by Kayser and Runge and by Rydberg, show us that, in many cases, we may be almost certain to obtain from the higgledy-piggledy arrangement of the lines in the spectrum of any one substance two or three beautiful regular series like those that I have already shown you in the case of helium and asterium. There is a little difference in the nomenclature employed by the investigators to whom I have referred, as shown in the annexed table.

*Series Nomenclature.*

| Intensity. | Kayser and Runge. | Rydberg. |
|---|---|---|
| Strongest ... | ... Principal series | Principal series |
| Weaker ... | ... 1st subordinate series | Nebulous series |
| Weakest ... | ... 2nd subordinate series | Sharp series |

The strongest lines which they observed at the temperatures they worked with, they put into what they call a "principal series," and then the weaker lines were distributed among other two series. Kayser and Runge called them the "first-" and "second-subordinate" series; Rydberg calls them the "nebulous-series" and the "sharp-series." It is important to remember this in case you come across any reference to these matters, in order that you may see what the exact equivalent is. The lines of the principal series almost always reverse themselves very easily indeed—that is to say, that the absorption is indicated by them more readily than it is by the other lines. Then, when we come to the second subordinate or sharp series, it is found that these sometimes broaden out towards the red end of the spectrum.

This work, of course, has required considerable investigation; the first attempts were not quite satisfactory, because the observations on which it was based had not been of sufficient accuracy. With greater dispersion it has been found that some of the lines which were supposed at first to be single are really double; so that it is quite usual now when we consider this question of series to suppose that in some cases the series are composed of single lines, in other cases of doubles, and in other cases of triplets; and it was at first, indeed, imagined that in these differences we were face to face with a very important physical difference between the various elements, but Rydberg has suggested that possibly after all it may be a difference merely in the seeing.

He says:[1]

"The difference between the doubles and triplets is only relative. This opinion is confirmed by the fact that the triplets appear often in the form of doubles, the most refrangible component not having sufficient intensity to become visible. Further, the relative intensity of the components of the doubles seems equal to that of the two less refrangible components of the triplets.

"For these reasons I have dared to propose the hypothesis that the two kinds of component rays are of the same order, or that the doubles are only triplets of which the most refrangible component is too feeble to be seen, or has perhaps the absolute value of zero. . . ."

[1] *Kon. Sv. Vet. Ak. Hand.*, vol. 23, ii. p. 135.

If the lines are more difficult to see, and if the sub-series of lines get stronger towards either the red end or the blue end, then we are more likely to see one line than two, and more likely to see two lines than three.

I have already referred to the many years old suggestion that a line is a remnant of a fluting. If you could see the whole fluting, you would see what is represented in the upper horizon of the diagram; if you

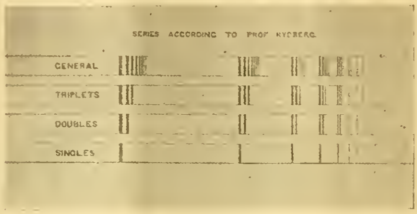



FIG. 5.—Diagram illustrating Rydberg's idea of the appearance of triplets, doubles, &c.

could not see the whole of it, you would get what is represented in the second horizon, that is to say, a triplet. If the third line were very difficult of observation you would only see a doublet, and if the inside line were weaker than the other you would only see a single line.

| Single lines | | Doubles | | Triplets | |
|---|---|---|---|---|---|
| Principal series | Subordinate series | Principal series | Subordinate series | Principal series | Subordinate series |
| Helium | | | Helium | Oxygen | Oxygen |
| Asterium | Asterium | Hydrogen (?) | Hydrogen | Sulphur | Sulphur |
| | | Lithium (?) | Lithium (?) | Selenium | Selenium |
| | | Sodium | Sodium | | Magnesium |
| | | Potassium | Potassium | | Calcium |
| | | Rubidium | | | Strontium |
| | | Cobalt | | | Zinc |
| | | | Copper | | Cadmium |
| | | | Silver | | Mercury |
| | | | Aluminium | | |
| | | | Indium | | |
| | | | Thallium | | |

There is only a very small number of the chemical elements which give us single lines; in the principal series, so far, we only know of helium and asterium: in the subordinate series we only know of asterium. The number of doubles, you will observe, is very much greater, but it is not so great in relation to the principal series as it is in the case of the subordinate series; but although we have nine elements giving us triplets in the subordinate series, we have only three which give them in the principal series.

*(To be continued.)*

## THE DOVER MEETING OF THE BRITISH ASSOCIATION.

THE final arrangements for this year's meeting are now sufficiently completed for a fairly accurate forecast to be made. Whether the meeting will be large or small it is still too early to judge, but whether large or small it will certainly be a very interesting one. As to accommodation in the town, there is little doubt but that at the time of meeting ample accommodation will be available, though the committee have had great difficulties in inducing hotel keepers and lodging-house owners to

reserve rooms for members of the Association, and have only partially succeeded. Dover being a sea-side resort, there has been a natural dislike on the part of owners of hotels and lodgings to offer to disturb those visitors who may possibly have come for a longer stay for the sake of members of the Association who may only wish to spend a week or so. There will, however, be accommodation available in Deal, Canterbury and Folkestone for those who cannot find rooms in Dover. It will be well, however, that intending visitors to the Dover Meeting should inform the local secretaries (E. Wollaston Knocker, C.B., and W. H. Pendlebury, M.A., Castle Hill House, Dover) of their intention, so that approximately the amount of extra accommodation may be known.

It has been usually the case that the secretaries of the various sections are accommodated at the same hotel to facilitate sectional arrangements. This year the Hospitality Committee has been able to arrange with the Head Masters and House Masters of Dover College to entertain the secretaries in the various boarding houses. Unfortunately, the accommodation is limited to the rooms usually occupied by the boys (each of whom has a separate bedroom to himself), so that it is impossible to take in secretaries accompanied by their wives. There will be a few other guests entertained by the Local Committee under the same conditions. The Masters of the various houses will act as hosts on behalf of the Hospitality Committee, and will look after the comfort of their guests. The College Masters will also give the first of the larger garden parties on Thursday, September 14. The Rev. J. N. Bacon has kindly undertaken to make a balloon ascent with objects similar to those which induced him to make an ascent at the Clifton College garden party. The situation of Dover with regard to the sea will doubtless add to the interest of such an ascent.

Lord Northbourne and Lord George Hamilton have kindly consented to allow members of the Association to inspect Betteshanger Park and Deal Castle respectively.

Owing to the fact that two of the days usually given up to excursions are required for the visit of the French Association to Dover and the return visit of the British Association to Boulogne, the number of excursions arranged for will be smaller than usual. The geologists and anthropologists have arranged a number of smaller excursions for the afternoons as usual, and these will, of course, not be interfered with. On the last day of the meeting (Wednesday) the Association is invited by the Dean and Chapter and Mayor and Corporation of Canterbury to pay a visit to that city to meet 200 members of the French Association, who will have previously been entertained to luncheon there. The Mayor and Corporation will entertain the British Association to tea. On the following day (Thursday) an excursion has been arranged to Rochester and Chatham Dockyard for those who do not care to go over to Boulogne. An opportunity will be given to visit the Agricultural College at Wye, near Ashford, which has been so successfully started by the County Councils of Kent and Surrey. The Principal, Mr. A. D. Hall, has invited members of the Association to pay the College a visit and inspect the experimental stations. It may be well to recall the fact that Wye College is especially included in the new University of London, though considerably outside the limit. For those members of the Association who visit Boulogne a most interesting programme has been arranged on the lines laid down in a former article (p. 181). The luncheon will be given by the civic authorities. The French Government has taken a great amount of interest in the gathering, and it is very likely that some prominent French statesman will attend to welcome the British Association in the name of the Government. In such case it is very likely that a similar compliment will be paid to the French Association on their visit to Dover. The French Government has also given instructions to the various Mayors and Prefects of the districts, through which the British Association will pass, in the five days' excursion at the conclusion of the meeting, to take official notice of the tour. The motor-car exhibition arranged by the Mayor of Dover for the Tuesday afternoon has been declared by the Board of Trade an international exhibition, so that no patents will be invalidated by premature disclosure at the Dover show. The French Association intends to give a considerable amount of attention to the automobile.

The Mayor of Dover will give a conversazione in the Town Hall and a garden party in the Connaught Park in addition to the reception at the motor-car exhibition.

The programme of local arrangements will be completed in a few days, and it will then be possible to make a fuller statement of the entertainments prepared for those members of the British Association who may visit Dover.

W. H. PENDLEBURY.

## "*THE WEST INDIAN BULLETIN.*"

IT was on August 2 of last year that Mr. Chamberlain announced in the House of Commons the decision of the Government, based on the recommendations of the West India Royal Commissioners, to create a special Department of Agriculture for the distressed Colonies, to be presided over by Dr. Morris, of Kew Gardens, who had acted as scientific adviser to the Commissioners. Immediately the proposals were sanctioned by Parliament, active steps were taken to vigorously carry out the scheme. By the middle of September Dr. Morris had left for Barbados, which had been selected as the headquarters of the new establishment, and tours were at once undertaken to ascertain the requirements of the several islands. The result was the organising of a conference of the authorities on agricultural matters in the West Indian Colonies, each island sending delegates to attend the meetings, which were held, under the presidency of Dr. Morris at Barbados, in January last. On the first anniversary of the day on which the Colonial Secretary publicly set the scheme in motion there arrived in this country the first number of the *West Indian Bulletin*, the journal of the Imperial Agricultural Department for the West Indies, a publication which it is intended to supply gratis to all residents in the islands who ask for it. Its prototype is, naturally, the *Kew Bulletin*, but apparently it will not be issued at regular monthly intervals, only as occasion may require. The first part is a double number of 141 pages, devoted almost wholly to the proceedings at the agricultural conference of January already referred to, the subejcts dealt with being primarily of interest to the Colonists. In addition to the presidential address, dealing generally with the objects of the new Department, there were papers by Prof. d'Albuquerque on "Sugar-cane manurial experiments," and "The teaching of agricultural science at colleges"; by Mr. Bovell on the "Field treatment of the diseases of the sugar-cane," and the "Cost of growing sugar-canes in Barbados"; by Mr. Fawcett on "Agricultural instruction in agricultural schools in Jamaica," "Practical field instruction in Jamaica," and "The prevention of the introduction and spread of fungoid and insect pests in the West Indies"; by Mr. Francis Watts on "Central factories," Mr. William Douglas also dealing with the same subject. The Rev. William Simms discussed "Agricultural education"; Dr. Alford Nicholls, C.M.G., "Suggestions for agricultural development in the Leeward Islands"; Mr. Hart, "Improvement in agricultural methods in the West Indies"; and Prof. Carmody made "Brief suggestions on Colonial industries." The bare recital of the titles of the papers will show what a wide field of investigation and action was opened out, and it behoves all who are interested in the future welfare of

these unfortunate Colonies to secure this first number of the *West Indian Bulletin*, carefully study the array of facts contained therein, and see whether it is not possible to do more for reviving the ancient glories of the islands by personal energy, and the adaptation of modern methods of culture and preparation for the markets of the world, than by any possible benefits that can accrue from abolishing the sugar bounties by France and other countries, or the imposition by us of countervailing duties in favour of our own Colonies. While it is extremely doubtful whether the removal of the bounties would benefit the West Indian sugar planters to any appreciable extent, it seems almost absolutely certain that if they resolutely determined on keeping abreast of the times in management, machinery, selection of plants, &c., instead of being content with what was thought good enough by their fathers and grandfathers before beet-sugar entered into the competition, they would soon see an end to the worst features of that perpetual millstone—the depression in the West Indian sugar industry. As Dr. Morris said in his opening address, "The sugar industry in the smaller islands will never be in a satisfactory condition so long as the processes of crushing the canes and manufacturing the sugar remain as at present." H.

## *SIR EDWARD FRANKLAND, K.C.B., F.R.S.*

NEWS of the death of Sir Edward Frankland will come as a surprise as well as a shock to all his friends, and will be received by the whole scientific world with feelings of the deepest regret.

The end came on Wednesday, August 9, in Norway, where Sir Edward had been in the habit of spending his summer holidays for many years. Born at Churchtown, near Lancaster, on January 18, 1825, he had entered upon his seventy-fifth year, but his upright, spare and active figure until quite recently gave the impression of a much younger man. It was noticeable, however, that he had aged in appearance perceptibly after the death of Lady Frankland (his second wife), which occurred rather suddenly in the spring of the present year.

Frankland received his early education at the Lancaster Grammar School, and subsequently became one of the first science masters at Queenwood College. From Queenwood he proceeded to Germany, and studied chemistry at Marburg and at Giessen. Returning to England he was appointed in 1851 first professor of chemistry at Owens College, Manchester, and there he remained for about seven years till his removal to London in 1857 to take charge of the chemical department in St. Bartholomew's Hospital Medical School. In 1863 he was appointed Fullerian Professor of Chemistry in the Royal Institution, and in 1865 he succeeded Hofmann at the College of Chemistry. The latter chair, which was soon afterwards transferred to the united School of Science and Royal School of Mines at South Kensington, he held till his retirement in 1885. Frankland was for many years a regular attendant at the meetings of the Chemical Society, and was president in 1871–72. His scientific work was rewarded also by honours from many foreign universities and academies, including the Institute of France, of which he was a corresponding member. For the last five years he held the office of Foreign Secretary of the Royal Society, and in 1894 he received the Copley Medal.

Sir Edward received the honour of knighthood in 1897, on the occasion of Her Majesty's Jubilee; but this, strange to say, was conferred, not in recognition of his very eminent services to chemical science, but in his more ordinary professional capacity as water analyst to the Home Department, having been for more than thirty years responsible for the annual reports to the Local Government Board on the quality of the metropolitan water supply.

Frankland's title to fame rests securely upon his important experimental investigations in pure chemistry accomplished chiefly within the twenty years from 1848 to 1868, and upon the impetus which was given to theoretical chemistry by the promulgation of his views concerning the combining capacity, or valency as it is now called, of the elements, which he derived from the results of his experimental work. In the years following 1840 the views of Liebig and of Dumas as to the nature of the carbon compounds, usually spoken of as organic, attracted the attention of the whole chemical world, and efforts were especially directed to the problem of how to isolate the compound radicals which they were supposed to contain in the form of oxide, hydrate, chloride, bromide, iodide and so forth. The radical of common alcohol was naturally one to receive early attention, and to this subject Frankland devoted his earliest efforts. He was successful in 1848 in isolating a substance to which he and all the chemists of that day gave the name *ethyl*, in the belief that it was really the radical of which common alcohol was the hydrate and common ether the oxide, and which was present as the characteristic basis of all the numerous compound ethers or ethereal salts then known. Though in strictness an error, long since corrected by applying the law of Avogadro, was involved in this assumption, the experimental method employed led to the further discovery of the remarkable series of compounds known as organo-metallic, and to the subsequent recognition of the varying power possessed by the metals and metalloids of uniting with alcohol radicals, with the halogens and with oxygen. The recognition of this diversity of combining capacity, and of the fact that each elementary atom possesses a maximum capacity beyond which its power of chemical union is incapable of extending, supplied the basis of the modern doctrine of valency and of all the consequences which follow from the idea of the orderly linking of atoms, afterwards developed by Kekulé into the theory of structure, upon which the whole system of organic chemistry is at the present day established.

At a later period Frankland pursued investigations in the then new and always difficult department of synthetical chemistry. In this he was associated for a time with Mr. B. F. Duppa.

Among others of his researches must be mentioned his experiments on the influence of pressure upon the luminosity of flame. These resulted in a theory of luminosity which for many years divided the favour of chemists and physicists with the older theory of Davy, according to which the luminosity of hydrocarbon flames, at least, is attributed to the presence in the flame of incandescent solid particles. Frankland's theory pointed to the effect of density in the ignited vaporous constituents of luminous flames.

Reference must also be made to the protracted and laborious study of gas and, especially, water supplies, which occupied so many of the later years of his life. Having been appointed a member of the Royal Commission on the Pollution of Rivers and Domestic Water Supply in 1863, he continued henceforward to give close attention to this important subject, and if his analytical methods and his conclusions were not universally adopted, he remained to the end of his life the most eminent authority on the chemical examination of water.

Sir Edward Frankland left several sons and daughters, among whom his eldest son, Dr. Percy Faraday Frankland, F.R.S., professor in the Mason University College, Birmingham, is distinguished as a scientific chemist.

The funeral will take place at Reigate on August 22.

## THE NATIONAL PHYSICAL LABORATORY.

THE realisation of the scheme for the establishment of a National Physical Laboratory is primarily due to two addresses delivered before the British Association in 1891 and 1895 by Prof. Oliver Lodge and the late Sir Douglas Galton respectively. The fact that Sir Douglas Galton, when president of the Association, did all in his power to support the proposal originally made by Prof. Lodge, led to the matter being laid before the Prime Minister by a strong deputation. A committee, of which Lord Rayleigh was chairman, was then appointed by the Treasury, and after taking evidence, reported in favour of the establishment of a public institution for standardising and verifying instruments, for testing materials, and for the determination of physical constants. They further recommended that the institution should be established by extending the Kew Observatory in the Old Deer Park, Richmond, and that the Royal Society should be invited to control it and to nominate a governing body, on which commercial interests should be represented, the choice of the members of such body not being confined to Fellows of the Society.

These recommendations were approved, and to give effect to them the Government undertook to ask Parliament for 12,000*l.* for buildings and for 4000*l.* a year. A scheme for the management of the new institution has been approved by the Treasury, and the first instalment of the promised grants has been sanctioned by the Legislature. The Kew Observatory Committee are willing that the Institution which they have managed very successfully should be merged in the National Physical Laboratory, which will thus become possessed of an endowment of 458*l.* per annum from the Gassiot Trust, and of an income of about 2700*l.* from fees for standardising. These receipts have, in the past, rather more than covered the expenses of carrying on the work of the Observatory.

The ultimate control of the National Physical Laboratory is placed in the hands of the Royal Society, but the constitution of the bodies which manage it directly can only be altered with the consent of the Treasury. These are an Executive Committee and a General Board. The latter is a relatively large body, to which the Executive Committee must report annually, and to which it must submit its scheme of work for the next year. An essential feature in the constitution of the General Board is that twelve of its members are nominated by six of the great technical societies—viz. the Institutions of Civil, Mechanical, Electrical and Naval Engineers, the Iron and Steel Institute, and the Society of Chemical Industry. Six of these representatives of "commercial interests" are also to be members of the Executive Committee, which will ultimately consist of twelve ordinary and five official members, of whom the latter are: the President of the Royal Society, the Chairman of the Committee, the Permanent Secretary of the Board of Trade, and the Treasurer and one of the Secretaries of the Royal Society. In the first instance, six members of the existing Kew Observatory Committee will also have seats on the Executive Committee, but their places will not be filled up when their period of office expires. Finally, it is in the power of the Executive Committee to appoint sub-committees to superintend particular departments or investigations. The members of these sub-committees need not necessarily be members either of the General Board or of the Executive Committee.

Preliminary arrangements have been in progress for some time in order that the National Physical Laboratory should be organised as soon as possible after the requisite funds were voted by Parliament.

The six technical societies have nominated their representatives, the General Board and Executive Committee have been constituted, and general satisfaction will be felt at the announcement that Lord Rayleigh has accepted the chairmanship of these bodies.

On the recommendation of the Executive Committee, the Council of the Royal Society has appointed Mr. R. T. Glazebrook, F.R.S., now Principal of University College, Liverpool, to the important post of Director of the National Physical Laboratory. A number of sub-committees have also been organised by the Executive Committee, which have been requested to make suggestions preparatory to the drawing up of a detailed scheme of work and of the plans of the new buildings.

The members of the Executive Committee are:—

Lord Lister, P.R.S., Lord Rayleigh (*Chairman*), Mr. A. B. Kempe, Treas. R.S., Prof. A. W. Rücker, Sec. R.S., and Sir Courtenay Boyle (*ex officio*), Captain W. de W. Abney, Sir N. Barnaby, Mr. G. Beilby, Sir E. H. Carbutt, Bart., Captain E. W. Creak, R.N., Prof. R. B. Clifton, Prof. G. C. Foster, Mr. F. Galton, Prof. O. J. Lodge, Sir A. Noble, Prof J. Perry, Sir W. Roberts-Austen, Prof. A. Schuster, Mr. A. Siemens, General Sir R. Strachey, Prof. J. J. Thomson, Dr. T. E. Thorpe, Sir J. Wolfe Barry.

In addition to the above, the following are also members of the General Board:—

Sir M. Foster, Sec. R.S. (*ex officio*), Sir F. A. Abel, Bart., Prof. W. G. Adams, Prof. W. E. Ayrton, Mr. H. Bell, Mr. A. Buchan, Mr. R. E. Crompton, Prof. G. F. Fitzgerald, Prof. J. Joly, Lord Kelvin, Mr. J. T. Milton, Sir W. H Preece, Mr. W. F. Reid, the Earl of Rosse, Dr. R. H. Scott, Mr. W. N. Shaw, Mr. C. E. Stromeyer, Admiral Sir W. Wharton, Sir W. H. White.

The following have also been requested to serve on one or other of the sub-committees above referred to:—

Messrs. E. D. Archibald, C. V. Boys, Prof. H. L. Callendar, Messrs. Forbes Carpenter, W. H. M. Christie, J. H. Dallmeyer, Prof. J. A. Ewing, Mr. S. Z. de Ferrant Prof. J. A. Fleming, Messrs. R. E. Froude, E. H. Griffiths, J. Mansergh, T. Matthews, W. H. Maw, Dr. L. Mond, Hon. C. A. Parsons, Prof. A. W. Reinold, Captain H. R. Sankey, Messrs. J. Swinburne, G. J. Symons, H. A. Taylor, Prof. S. P. Thompson, Messrs. J. I. Thornycroft, C. H. Wordingham and A. F. Yarrow.

It will thus be seen that the National Physical Laboratory is being founded on a wide basis. A definite scheme of work will be arranged during the autumn. The Director will, it is hoped, take up the duties of his office on January 1, 1900, and the planning and erection of the new buildings will then proceed with as little delay as possible.

## NOTES.

WE regret to learn that Prof. Bunsen, the veteran chemist, is lying seriously ill at his residence in Heidelberg, and that little hope is entertained of his recovery.

M. DE FONVIELLE, writing from Paris, says: "M. Janssen has left Paris for his usual annual journey to the Observatory on the summit of Mont Blanc, to inspect the instruments installed there.—The Minister of Finance granted to MM. Hermite, at Besançon, the sum of fifty pounds for their experiments with free balloons. It is intended to send up a balloon with new recording apparatus during the forthcoming meeting of the French Association at Boulogne."

MR. BALFOUR has consented to take the chair at a festival dinner at the end of November in aid of the fund now being raised to provide new laboratories at King's College, London.

THE autumn meeting of the Iron and Steel Institute was opened at Manchester on Tuesday, under the presidency of Sir William Roberts-Austen, K.C.B., F.R.S.

THE Superintendent of the U.S. Coast and Geodetic Survey has designated Dr. Frank Schlesinger, Columbia University, New York City, to take charge of the variation of latitude observations at Ukiah, California, in accordance with the plans of the International Geodetic Association.

IT is with great regret that we learn of the death of Dr. Daniel G. Brinton, the distinguished and erudite American anthropologist, in his sixty-third year. Although Dr. Brinton was for many years Professor of American Archæology and Linguistics in the University of Pennsylvania, we understand that he had very little actual teaching to do, and thus was at liberty to devote himself to research. Dr. Brinton was known as an enthusiastic student of linguistics, and had a profound knowledge of American languages. He had recently bequeathed his extensive and very valuable linguistic library to his University The following are some of his contributions to anthropological science: "The Floridean Peninsula: its Indian Tribes and Antiquities"; "The Myths of the New World" (third edition, 1896); "The Religious Sentiment: a Contribution to the Science of Religion"; "American Hero Myths"; "The Chronicles of the Mayas"; "The Annals of the Cakchiquels"; "Ancient Nahuatl Poetry"; "Races and Peoples"; "Lectures on Ethnography"; "Essays of an Americanist"; "The American Race"; "The Pursuit of Happiness"; "Nagualism"; "Grammar of the Choctaw Language"; "Grammar of the Cakchiquel Language," and various other papers and memoirs.

A HURRICANE of unusual severity struck the island of Montserrat, West Indies, on the 7th inst., and caused great devastation there and at other points of its path. It is reported to have reached Porto Rico on the 8th, to have been central over the north-east of Cuba on the 10th, and to have reached the southern part of Florida on the 12th. As pointed out in our note of July 20 last (p. 281), West India hurricanes are most prevalent at this season of the year; the average number between August and November is two a month, but the tracks are often over the open sea, and do not come in contact with the numerous islands. The course taken by the storm in question was more to the northward of the hurricane which caused so much damage at Barbados and St. Vincent last September, and has taken a somewhat more westerly route than the average path. The rate at which it travelled seems to have been under ten miles an hour, which is about the usual velocity in those latitudes; but this has no relation to the force of wind in the whirl of the storm, which probably reached a rate of 100 miles an hour at times. By a telegram from New York on the 12th, the fury of the storm appeared to have abated, probably owing to contact with the land; but for further particulars as to its behaviour, we must wait for the official reports of the Governors of the various islands and of the United States authorities.

PROF. E. VAN AUBEL, assistant professor of physics in the University of Ghent, sends us an interesting note with reference to Dr. C. G. Knott's recent experiments on magnetic strain in bismuth (p. 192) and Mr. Shelford Bidwell's comment upon them (p. 222). It appears that, in 1892, Prof. van Aubel prepared a paper on the same subject, entitled "Influence de l'aimantation sur la longueur d'un barreau de bismuth," and it was published in the *Journal de physique théorique et appliquée* (troisième serie, tome i. p. 424, 1892). His experiments were made with perfectly pure bismuth, prepared by electrolysis, and used by Prof. A. Classen for the determination of the atomic weight of the metal. An interference method was employed to determine any change of length, but no change was found. Prof. van Aubel expresses his satisfaction that the results of his investigation have now been confirmed by Mr. Shelford Bidwell's new experiments.

THE value of towing experiments upon small-scale models of ships for the purpose of deducing the resistance of a full-sized ship from that of the model was first demonstrated by the late Mr. William Froude, whose son, Mr. R. E. Froude, F.R.S., is the superintendent of experiments of this kind at the Admiralty Experimental Works, Gosport. The Construction Bureau of the United States Navy Department has appreciated for many years the value of an experimental basin, but it was unable to secure a grant for the purpose until about two years ago, when Congress granted 100,000 dols. for this work. The basin proper was finished towards the close of last year, and the special machinery and apparatus have now just been completed and installed, after a good deal of delay, due indirectly to the war with Spain. The basin is situated in the Washington Navy Yard, but the building is 500 feet long and about 50 feet wide inside. The water surface of the basin is slightly shorter than the building, being about 470 feet long. The deep portion is about 370 feet long, the south end, from which runs begin, being shallow. The water surface is 43 feet wide, and the depth from top of coping to the bottom of the basin is 14 feet 8 inches. The basin is thus larger than any other in existence, and it is well equipped with machinery for the performance of experiments. Electricity is used to drive the overhead carriage which tows the models; in fact, it is used for all mechanical work in connection with the model tank. Experiments are now being made to determine frictional coefficients of varnished surfaces and other constants needed in the use of the basin. Experiments are also being made as opportunity serves upon models of the naval vessels already built and tried for the purpose of accumulating data which will be constantly needed during the life of the tank.

AN important paper has been recently communicated to the Swedish Academy of Sciences by Dr. Hildebrandsson, Director of Upsala Observatory, entitled "Researches on the centres of action of the atmosphere: II. Rainfall." In a previous paper, published in 1897, it was shown that an intimate relation exists between the variations of barometric pressure in different regions of the earth, *e.g.* if the pressure of the air is above or below the mean at the Azores, the reverse condition would obtain between Iceland and Scotland; and similarly for other parts of the world. Rainfall is perhaps the most important element in the economy of nations, but it is apparently the most variable and irregular of all when dealt with for short periods, but for seasons, or longer periods, considerable regularity is observed. The paper contains tables and curves showing seasonal and yearly values of rainfall for a number of places; and from these it is seen, for instance, that as regards Iceland and the Azores the variations in the rainfall during the cold season are almost always in the opposite direction, and equally clear results are shown to exist for other localities. It is evident that a prediction of rainfall six months in advance would be of great utility in India. With regard to those regions, the author finds that the amount of rainfall between October and March in Siberia is generally in inverse proportion to the amount which will fall in India during the following rainy season. It is not pretended that any definite laws have been determined, but the provisional results seem to be of sufficient importance to warrant a more detailed inquiry.

MR. W. E. HOYLE, Director of the Manchester Museum, Owens College, has presented a very satisfactory report upon the progress made during 1898. The museum is not merely a popular resort, but also an institution which works in many

ways for the advancement of science. The most important gift to the museum during last year was a collection of birds which formed the basis of Mr. H. E. Dresser's work on "The Birds of Europe," and his monographs of the Rollers and of the Bee-eaters. Neither trouble nor expense was spared to make the collection as complete as possible, and more particularly to make it a working collection. As regards the extent of the collection, there are of Bee-eaters about 30 species and 155 specimens, and of Rollers 26 species with 112 specimens; whilst the Western Palæarctic collection contains 721 and the Eastern 260, making a total of 1037 species, or more, according to the British Museum Catalogue. In almost every instance these forms are represented not merely by a single skin but by several, showing the differences of plumage due to sex, age, and local variation, the collection amounting in total to some 10,000 specimens. There are several types and numerous rarities, among which may be mentioned two specimens of the Rosy Gull, whose nesting-place was discovered by Nansen in Franz Josef Land, and two Labrador Falcons. Mr. Hoyle rightly points out that the acquisition of this valuable collection is a piece of singular good fortune for the Manchester Museum, and therefore for all students of ornithology in the neighbourhood.

Some interesting experiments on the corrosion of metals by sea water have (says *Engineering*) been carried out at Kiel during the past two years. The plan followed was to cut off twelve specimens of the metal to be tested, of which three were kept as "witnesses," whilst the other nine were placed in salt water. At the end of eight months three of the latter were withdrawn and compared with the "witnesses." Eight months later a second set were withdrawn and a fresh comparison made, those then left being taken out after the lapse of a third period of eight months. The metals tested included alloys of copper rich in zinc, bronzes containing little zinc, bronzes containing no zinc, pure aluminium bronzes, and finally bronzes containing aluminium and zinc or zinc and iron. The latter in particular showed remarkable resistance to the corrosive powers of sea water, being practically untouched at the end of a two years' immersion. The alloys containing zinc, however, gave much less favourable results. The copper-tin alloys and copper-aluminium alloys and the iron bronzes resisted perfectly when immersed in sea water in contact with iron. The bronzes containing iron, when placed in contact with those of tin, showed a loss by corrosion. It is thus important, if corrosion is to be prevented, to avoid placing these alloys in contact with metals electro-positive to them.

An account of the application of liquefied carbonic acid gas to extinguish underground fires was given by Mr. George Spencer at the recent meeting of the Institution of Mining Engineers. At a colliery with which Mr. Spencer was connected a fire occurred in a heading, as the result of a fall of roof and sides on steam-pipes. The heading was built off with as little delay as possible, but notwithstanding all efforts to shut out the air, sufficient reached the seat of fire to keep it burning slowly. It was therefore decided to apply carbon dioxide, and for this purpose six cylinders of liquefied gas were successfully used. It is not claimed that the method described can be successfully applied to all gob-fires, but there are undoubtedly many cases which might be so treated. In case of fire on shipboard the use of carbon dioxide would no doubt prove invaluable, as it could be quickly applied, and would not cause the same damage to cargoes as water.

The numbers of the *Kew Bulletin* just issued (Nos. 144–146) contain several articles and items of information which serve to show the influence which Kew exerts on botanical science and plant industries in many parts of the world. The life-history of a parasitic fungus which for the past two years has destroyed a considerable number of examples of the beautiful flowering shrub *Prunus japonica*, Thumb., growing in Kew Gardens, is described by Mr. G. Massee, and preventive measures of dealing with it are given. An account is given of experiments made in Queensland for the improvement of the sugar-cane by chemical selection upon a method proposed by Sir William Thiselton-Dyer. The object of the experiments was to ascertain the possibility of increasing the average richness and purity of the juice of a given variety of sugar-cane, by chemical analysis of the juice from each of the "seed canes"—that is, canes from which the plants were to be taken—and by the selection of those plants from the seed canes which were found by the analysis to yield the richest and purest juice. The results of the experiments show clearly that canes planted from rich seed canes selected in this way yielded a juice of higher sucrose content and lower glucose content than canes planted from those shown chemically to be of a "low" grade.

Three new analyses of moldavite glass are published by Dr. C. v. John in the *Verhandlungen der k.k. geolog. Reichsanstalt*, Nos. 6 and 7, 1899. The specimens were handed over by Dr. F. E. Suess for investigation, and with them a specimen of glass from Netin in Moravia, received from Prof. Dvorský, of Brünn. This glass fragment, considered by Drs. Dvorský and Suess to be of artificial origin, was analysed in order that its chemical composition might be compared with that of true moldavite. Similar fragments of artificial glass have been frequently mistaken for moldavite, but differ from the latter in the absence of the characteristic surface sculpture, as also by the different shade of colour. The three specimens of moldavite showed a strikingly similar chemical composition, in which the potash was considerably in excess of the soda. The glass fragment from Netin showed a very different composition, and proved to be a potash glass in which the percentage of potash was abnormally high. The percentage of silica, potash, and soda in moldavite from Budweis was 82·62, 2·28, and 0·63 respectively, while the artificial glass yielded silica 52·32, potash 22·84, and soda 0·24 per cent. The author appends a table containing all the analyses of moldavite known to him, and draws attention to the similarity of composition shown. He remarks that the iron occurs for the most part as ferrous oxide, and that ferric iron is found in larger quantities only in those varieties having a strong brown colour. The belief is expressed that in moldavite the potash is always in excess of the soda, and the author states that in all cases the sum of the alkalis contained is found to be very similar.

In the same number of the *Verhandlungen* is published a paper by A. Rosiwal, in which some additional results of his technical investigation of building-stones are described. In this paper the author clearly explains his new method whereby the relative "freshness" and "degree of weathering" of various building-stones may be expressed in figures. This ingenious method consists in the application of simple formulæ, and it is clearly illustrated by numerous examples.

Dr. Davison's report on the Hereford earthquake of 1896 contains a brief note, by Mr. E. Greenly, on the relation between the intensity of the shock and the geological structure of the Bangor-Anglesey district. In a paper recently published in the *Transactions* of the Edinburgh Geological Society, Mr. Greenly gives the evidence at greater length. He shows that the shock was felt most powerfully in houses standing upon Carboniferous and Ordovician rocks, less so in those upon the hard volcanic series of Bangor, and least of all in the Schistose Complex of Anglesey; the general result being that "the shock

was felt inversely to the degree of elasticity of the rocks." It was, moreover, stronger in the neighbourhood of large boundary faults, where effects due to reflexion would tend to be well-marked. Mr. Greenly also makes the interesting suggestion that, in their passage to the Bangor-Anglesey district, the earth-waves must be influenced by their having to traverse the older palæozoic rocks of the Snowdonian synclinal fold.

DESPITE the important influence of modern theories of oscillatory discharges on our knowledge of the phenomena of lightning, but few attempts seem to have been made to present in a readable and concise form recently observed facts, both theoretical and experimental, bearing on the important question of lightning protection. The Weather Bureau of the United States Department of Agriculture has done good service in publishing, in the form of an illustrated pamphlet of seventy-four pages, a bulletin on "Lightning and the Electricity of the Air," prepared under the direction of Mr. Willis L. Moore. The first part, by Mr. Alexander G. McAdie, is occupied chiefly with theoretical considerations, and includes descriptions of various forms of kites used for modern repetitions of Franklin's experiment, investigations of the potential of the air made on the Washington Monument and elsewhere, notes on auroral displays, photographs of lightning flashes, and a full summary of the best forms of lightning conductors, of general directions for the erection of rods, of precautions to be observed in thunderstorms, and of the treatment of patients struck by lightning. A brief account of the principles of lightning arresters and the use of choke coils for alternating current-circuits concludes this part.

PART II. of the bulletin referred to above, by Mr. Alfred J. Henry, deals with statistics of loss of life and property by lightning, both in the United States and in Europe. It calls attention to the danger to live stock caused by wire fences, the effects of the soil, the kind of trees usually struck (under which head the susceptibility of oaks is prominently shown) and the question as to whether the danger of lightning stroke is increasing or decreasing. In the last question a distinction is made between "cold" strokes and those which cause fire, and it would appear that in Bavaria the total number of strokes is on the increase, but the percentage of fire-causing strokes is on the decrease. This section is illustrated by photographs showing the effects of lightning on different trees, and a map showing the relative frequency of thunderstorms in different parts of the United States.

WE have recently received from Messrs. Williams and Norgate the annual number of *Mittheilungen der Naturforschenden Gesellschaft in Bern* for 1897. In it M. L. Crelier contributes a paper on the Bessel's function of the second kind $S_n(x)$, in which are deduced a number of formulæ involving Bessel's functions, which the author claims to be new. An account of the exhumation of the late Jacob Steiner is also given, accompanied by measurements of the great mathematician's skull.

PROF. AUGUSTO RIGHI contributes to the *Rendiconti* of the Bologna Academy a paper on the absorption of light on the part of a gas placed in a magnetic field. This forms a continuation of Prof. Righi's investigations on the Zeeman effect. The new experiments, conducted with the aid of a large Rowland's grating, deal chiefly with the inverse of Zeeman's phenomena, both with hypoazotid and with polarised light in sodium vapour. The investigation has an important bearing on results previously obtained by Macaluso and Corbino.

M. E. H. AMAGAT, writing in the *Journal de Physique* for July, proposes a new form of the relation $f(p, v, \mathrm{T})=0$ for fluids. From considerations, partly theoretical and partly experimental, M. Amagat is led to adopt the formula

$$\left\{p+\frac{v-[a+m(v-b)+c/(v-b)]\mathrm{T}}{kvr-\alpha+n\sqrt{[(v-\beta)^2+d^2]}}\right\}v=\mathrm{RT},$$

a formula which, in the case of carbonic acid, agrees closely with observations of the pressures corresponding to given volumes and temperatures, both in the gaseous state and along the curve of saturation.

A NEW classification of the Tineæ of Central Europe is given by Dr. Arnold Spuler in the *Sitzungsberichte der physikalisch-medicinischen Societät* (Erlangen) for 1898. Dr. Spuler follows modern views in placing the large Cossidæ among the Tineæ next before the family Tortricoidæ.

WE have just received two new parts of the *Bulletin* of the New York State Museum (vol. vi. Nos. 26 and 27, April and May 1899). Both are by Dr. Ephraim Porter Felt, State Entomologist. The first relates to the collection, preservation, and distribution of New York insects, and contains illustrations of apparatus. The second concerns shade-tree pests, and relates to various Coleoptera, Lepidoptera, Hymenoptera, and Hemiptera. It is illustrated, though it is but a small pamphlet, with five admirable plates, besides figures in the text.

THE volume containing the numbers of the *Bulletin of Miscellaneous Information* issued by the Royal Gardens, Kew, during 1898, has just been published. Many of the articles in this most serviceable publication have already been referred to in these columns, and we need now only call attention to the issue of them in a form convenient for reference. Particular attention is given in the volume to the cultivation of rubber plants, artificial indigo, China grass, and other subjects of economic importance.

THE seventh Robert Boyle Lecture on the "Physiological Perception of Musical Tone," delivered before the Oxford University Scientific Club on June 6, by Prof. J. G. McKendrick F.R.S., has been published in pamphlet form by Mr. Henry Frowde. An abstract of the lecture appeared in NATURE of June 15.

THE publication of a series of "Studien und Skizzen aus Naturwissenschaft und Philosophie," by Dr. Adolf Wagner, has been commenced by the firm of the Gebrüder Borntraeger, Berlin. The first volume is an essay "Über wissenschaftliches Denken und über populäre Wissenschaft," which should be read by persons who instruct the scientific laity by spoken or written words; and the second volume is concerned with the "Problem der Willensfreiheit." A number of other volumes are in preparation.

A DESCRIPTIVE catalogue of the Tunicata in the Australian Museum, Sydney, N.S.W., prepared by Prof. W. A. Herdman, F.R.S., has been published by order of the Trustees of the Museum. The collection upon which the catalogue is based was sent to Prof. Herdman several years ago, but certain circumstances prevented the publication of the work in 1893, when it was ready for press. The work is not put forward as a monograph on Australian Tunicata, so the only anatomical and histological details included are those required for the description of the various species. A list of the Tunicata Fauna of Australian seas, so far as it is at present known, is given, and also a brief general account of the structure and life-history of a typical Ascidian, which may be of service to students referring to the catalogue. Numerous plates illustrate the various species described.

THE additions to the Zoological Society's Gardens during the past week include a Pinche Monkey (*Midas aedipus*) from

Colombia, presented by Mr. R. E. Stone; two Common Duikers (*Cephalophus grimmi*), six Swainson's Francolins (*Pternistes swainsoni*) from South Africa, presented by Mr. J. E. Matcham; a Suricate (*Suricata tetradactyla*) from South Africa, a Common Hamster (Albino) (*Cricetus frumentarius*), European; an Antillean Boa (*Boa diviniloque*) from the West Indies, deposited; two Spotted Turtle Doves (*Turtur suratensis*), bred in the Gardens.

## OUR ASTRONOMICAL COLUMN.

HOLMES' COMET 1899 *d* (1892 III.).

*Ephemeris for 12h. Greenwich Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ ″ | Br. $r^{-2}$ | Br. $(r\Delta)^{-2}$ |
|---|---|---|---|---|
| August 17 | 2 51 17·17 | +36 29 53·4 | | |
| 18 | 52 16·44 | 36 45 24·3 | | |
| 19 | 53 14·43 | 37 0 51·8 | | |
| 20 | 54 11·12 | 37 16 15·8 | 0·1905 | 0·04889 |
| 21 | 55 6·48 | 37 31 36·3 | | |
| 22 | 56 0·47 | 37 46 53·2 | | |
| 23 | 56 53·06 | 38 2 6·3 | | |
| 24 | 2 57 44·22 | +38 17 15·7 | 0·1888 | 0·04999 |

MOTION OF APSE LINE OF $\alpha$ GEMINORUM.—In a previous communication to the *Mem. Soc. Degli Spett. Ital.* (vol. xxvi., 1897), M. A. Belopolsky has drawn attention to the rapid motion of the line of apsides in the system of $\alpha$ Geminorum (Castor), and now, in the last issue of the same journal (vol. xxviii. pp. 103–108, 1899), he gives the results of more recent work on this interesting double star. The former measures were obtained from a series of spectrographs obtained at Pulkowa during one year, and were not sufficiently representative to give certain results. He has now at his disposal observations which he has made during the past three years, and in the present paper confines himself to the examination of three groups of these observations, reserving the discussion of the whole for a later article. These groups of observations embrace the periods: (1) 1896, March 8 to April 26; (2) 1898, March 15 to May 2; (3) 1899, January 19 to April 16. In the calculation several difficulties are found, the chief of which are the rapid movement (period 2·93 days), the uncertainty of a few thousandths of the period producing an error of several degrees in the true anomaly, and also the uncertainty of the time of passage through *Periastron*.

Tables are given showing comparisons between the calculated and observed values for the velocity in the line of sight, for all the dates in the three groups of observations, from which the author concludes that the probable error is only about ± 0·368 l.g. (± 0·92 miles). He finally concludes that the observed rapid movement of the line of apsides is real, and that the *period of this revolution* is

4 years 40 days = 2100 days.

He attributes the cause of this to the probable flattening of the components, and mentions that a flattening of one-seventh would be sufficient, if the dimensions of the system are equal to those of Algol, to produce the observed motion.

MR. TEBBUTT'S OBSERVATORY.—In presenting his report of the work done at his observatory at Windsor, New South Wales, during the year 1898, Mr. John Tebbutt states that the past year was remarkable for the large number of clear nights during the autumn, winter and spring months, rendering it possible to get a large amount of work done.

Meridian work was carried out with a 3-inch Cooke transit, the timekeeper being a Poole 8-day chronometer.

Extra-meridian work consisted of observations of occultations, planets, and comets. With the 8-inch equatorial thirty-six disappearances at the moon's dark limb were measured and the results published. The same instrument, in conjunction with the Grubb filar micrometer, was employed on fifty-seven nights in planetary observation; 73 comparisons of Vesta, 211 of Iris, 107 of Isis, 91 of Jupiter and $\eta$ Virginis, 132 of Uranus and $\omega^1$ Scorpii, and 132 of Uranus and $\omega^2$ Scorpii, were recorded; and comparisons with the measures published by other observers have proved to be very satisfactory.

The observations of comets have been made with both the 4½-inch and 8-inch equatorials, and have included measures of Encke's Comet, and Comet Coddington-Pauly, the latter being followed from June 15 to March 3, 764 measures of the comet and 138 of comparison stars being made on 103 nights during that period.

Attempts to observe Comets Perrine, *e* and *h*, 1898, were unsuccessful owing to their proximity to the sun.

All the observations, computations and reductions have been made by the proprietor of the observatory, it being extremely difficult to obtain even occasional assistance.

TEMPERATURES IN GASEOUS NEBULÆ.—Mr. F. E. Nipher, in a paper read before the Academy of Science, St Louis (vol. ix., No. 4), discussed the conditions of temperature, &c., in a gravitating nebula having *uniform temperature* throughout its mass. In a second paper he now discusses the same subject on the different assumption that the initial temperature *diminishes* from the centre outwards. After a lengthy mathematical discussion he derives a general formula

$$T = T_0(1+n)\left(\frac{r_0}{r}\right)^{1-n}$$

which reduces to Ritter's equation if the temperature of the mass be assumed initially uniform. He concludes that in general the temperature throughout a nebula is to be given in terms of the coordinates of the point in space where the temperature is to be determined, and the *ratio of contraction* from any given initial condition. If the temperature remains constant throughout the mass, then Ritter's equation would hold during contraction. If on account of unequal permeability to heat the temperature should become unequal, the law of temperature change as a function of the ratio of contraction becomes more complex, so that if at any time the temperature varies inversely as the *n*th power of the distance from the centre, the ratio of temperature change at any contracting surface will be given by the above equation, in which it is evident, from physical conditions, that $n$ cannot be less than zero.

## THE RECENT PERSEID METEORIC SHOWER.

A SERIES of very clear nights enabled the Perseids to be well observed this year. The shower was not of unusual brilliancy, but it furnished a considerable number of meteors, and they appear to have been widely observed. The occurrence of the Perseid display now excites not only the attention of the meteoric enthusiast, but is seriously observed by astronomers generally, and the application of photography to work of this kind has greatly stimulated the interest in it.

On August 9 the writer watched the north-eastern sky between about 10h. 15m. and 13h., but a few clouds prevailed during the first hour. 38 meteors were seen, of which 26 were Perseids. On August 10, between about 10h. and 13h. 30m., 91 meteors were seen, of which 72 were Perseids. On August 11, between 10h. and 13h. 30m., 90 meteors were observed, including 68 Perseids. On August 12, between 10h. and 13h. 30m., 62 meteors were counted, and amongst these were 43 Perseids. On August 13, 23 meteors (10 Perseids) were seen in 2 hours, and on August 14, 29 meteors (12 Perseids) were recorded in 2¼ hours.

On August 10, between 11h. 10m. and 14h. 35m., Prof. A. S. Herschel at Slough observed 104 meteors, and after making allowance for time spent in registering the paths the horary number of meteors for one observer would be about 40. He describes the maximum as having been observed between 12h. and 12h. 30m., when several bright meteors succeeded each other at short intervals.

On August 10 Mr. T. H. Astbury, observing at Shifnal, Salop, says that thirty-four meteors were seen between 10h. and 11h., the great majority being Perseids. There was also an active radiant in Cygnus.

On August 11 only about eighteen meteors were seen from 10h. till 11h., so that he concluded the maximum occurred on the 10th, when the meteors were brighter and more numerous.

According to the Bristol observations already alluded to, very little decline in numbers was, however, noticed on August 11, and to exhibit this more readily, the following table has been compiled:—

| Date. | Time of observation. h. h. | Actual length. hrs. | Meteors seen. | Perseids. | Radiant. α | δ |
|---|---|---|---|---|---|---|
| Aug. 9 | $10\frac{1}{4}$–$12\frac{3}{4}$ | 2 | 38 | 26 | 44° | + 57° |
| 10 | 10 –$13\frac{1}{2}$ | 3 | 91 | 72 | 44 | + 57 |
| 11 | 10 –$13\frac{1}{2}$ | 3 | 90 | 68 | 46 | + 57 |
| 12 | 10 –$13\frac{1}{2}$ | 3 | 62 | 43 | 48 | + 57 |
| 13 | 10 –$12\frac{1}{2}$ | 2 | 23 | 10 | 49 | + 58 |
| 14 | 10 –$12\frac{1}{2}$ | $2\frac{1}{4}$ | 29 | 12 | 50 | + 56 |

The meteors seen on the 10th were, however, rather brighter on the whole than those on the 11th. The largest meteors were as follows:—

| No. | Date. | Time. | Mag. | Path. From | | To | |
|---|---|---|---|---|---|---|---|
| 1 | Aug. 9 | 11 4 | ♃ | 15° | + 28° | 11° | + 21 |
| 2 | | 11 32 | ♃ | $296\frac{1}{2}$ | + 57 | 278 | + $36\frac{1}{2}$ |
| 3 | | 12 7 | ♀ | 239 | + 60 | 235 | + 37 |
| 4 | Aug. 10 | 10 14 | ♀ | 293 | + 60 | 271 | + 38 |
| 5 | | 10 54 | ♃ | $23\frac{1}{2}$ | + 38 | 17 | + 29 |
| 6 | | 11 36 | ♃ | $49\frac{1}{2}$ | + $37\frac{1}{2}$ | $50\frac{1}{2}$ | + 32 |
| 7 | | 13 18 | ♃ | 50 | + 67 | 58 | + 73 |
| 8 | Aug. 11 | 11 9 | ♃ | $18\frac{1}{2}$ | + 51 | 5 | + $44\frac{1}{2}$ |
| 9 | Aug. 12 | 10 16 | ♃ | $5\frac{1}{2}$ | + 6 | 1 | − 6 |
| 10 | | 10 39 | ♃ | 326 | + $1\frac{1}{2}$ | 318 | − 11 |
| 11 | | 12 $1\frac{1}{2}$ | ♀ | $4\frac{1}{2}$ | + 43 | 347 | + $27\frac{1}{2}$ |

No. 3 was also seen by Prof. Herschel, and No. 4 by Mr. Astbury. The majority of the remainder were seen by various other observers, and their real paths will be calculated.

On August 12 the shower had markedly declined, though it was tolerably active between 10h. and 11h. The position of the radiant point exhibited the usual diurnal motion to the eastward. On July 29–August 2, eight meteors observed at Bristol denoted the radiant at 34° + 54°, and on August 6, six meteors fixed it at 40° + 55°. On August 12 it was in 48° + 57° and on August 14 in 50° + 56°.

Several remarkable meteors with very slow motion, and leaving trains of sparks, were recorded on August 12. One of the most striking of these appeared at 12h. 31m. It was of the 1st mag., and traversed a path of 33 degrees from 341° + 81° to 124° + 64° in about seven seconds. As it fell almost perpendicularly down the northern sky the nucleus poured out a stream of yellow sparks. Probably the radiant was near the southern horizon, and it is hoped that other observers will send in reports of this curious meteor, and enable its true radiant to be found.

Altogether the display seems to have been of average importance, and to have fallen below the observed strength of the shower on August 11, 1898. Many of the minor showers of the period made themselves apparent, though they were generally very feeble. The principal of them were at 41° + 20°, 333° + 26°, 345 ± 0, 315° + 77°, 339° 11° and 17° + 31°. It is to be hoped that at places where the photographic method has been applied the results have been successful.

W. F. DENNING.

## *UNITED STATES DEEP-SEA EXPLORING EXPEDITION.*

THE announcement that the U.S. Fish Commission steamer, *Albatross*, would shortly be despatched on an exploring expedition to the Pacific Ocean, has already been noticed in these columns. Particulars of the main objects of the expedition, and the route to be followed, are given by Mr. H. M. Smith in the *National Geographic Magazine*, from which the subjoined account has been abridged.

The *Albatross* is the best-equipped vessel afloat for deep-sea investigation, for which work she was especially constructed for the Fish Commission in 1882, at a cost of nearly 200,000 dollars. She is a twin-screw steamer of 384 tons burden, 234 feet long and $27\frac{1}{2}$ feet beam. A full account of the construction of the *Albatross* and her appliances for marine investigation has been given in the admirable work on "Deep-sea Exploration," by Commander Z. L. Tanner, U.S.N., under whose direction the vessel was built and who was in command from the date of her launching until 1894. The reputation long enjoyed by the *Albatross* of being unequalled in effectiveness for marine research will be more than ever deserved on the approaching cruise because of the extensive improvements and repairs she has recently undergone, including the installation of new boilers, ice-making machine, cold-storage plant, &c., together with the thorough replenishing of the scientific outfit.

The *Albatross* will pass through the Golden Gate on August 21 and begin her long voyage to certain groups of islands in the middle of the Pacific Ocean, both north and south of the equator, whose local fauna is almost unknown, while in the adjacent waters little or no scientific investigation has been carried on. The Society islands will be first visited, although the vessel will touch at the Marquesas islands for coal. Between San Francisco and Tahiti, a distance of 3500 miles, dredging and sounding will be carried on at regular intervals on a section of the sea-bottom almost wholly unexplored. Tahiti will be the headquarters while the Society islands and the Paumota islands are being explored. In the latter archipelago, which is about 600 miles long, six or eight weeks will be spent and important scientific discoveries should be made. In the Tonga or Friendly islands, distant about 1500 miles from the Society group, a week or ten days will be passed. The vessel will then proceed to the Fiji islands, where a short stay will be made, and thence 1700 miles to the Marshall islands, in which interesting archipelago, of whose natural history almost nothing is known, six or seven weeks will be devoted to exploration. The Ellice and Gilbert islands, lying between the Fiji and Marshall islands, will also be visited. It was originally the intention to have the *Albatross* proceed from the Marshall islands to the Hawaiian islands and thence to San Francisco, running a line of deep-sea dredgings along the entire route; but, owing to the prevalence of head winds at the time when the vessel will be ready to leave the Marshall islands, this plan has been abandoned, and instead the vessel will sail for Japan, making frequent use of the dredge and the deep-sea tow-net and setting the trawl in the moderately deep water off the Japan coast, where the fishermen are continually bringing up curious forms. The voyage of nearly 20,000 miles will come to an end at Yokohama, where the *Albatross* will arrive in April 1900, and refit for a summer cruise to Alaska to resume the systematic examination of the salmon streams begun several years ago.

The leading features of the expedition will be deep-sea dredging, trawling, and sounding, and some special appliances for such work have been constructed. A wire dredge-rope 6000 fathoms long has been made to order, and to accommodate this enormous quantity a special drum has had to be prepared. It is expected that both the dredge and the beam-trawl will be hauled in deeper water than heretofore. One of the novel pieces of collecting apparatus is a beam-trawl of unprecedentedly large size, especially designed for the capture of larger animals than can be taken with the usual apparatus.

While the deep-sea investigations will receive the most attention, surface and intermediate towing, shore-seining, and fishing trials with lines, gill-nets, and other appliances will be regularly carried on and will undoubtedly yield rich collections. The region to be visited abounds in atolls and elevated reefs, many of which will be visited and studied for the purpose of obtaining data bearing on the disputed question of the origin of coral reefs.

The *Albatross* is manned by about ten officers and seventy petty officers and enlisted men of the United States Navy. The commanding officer is Lieutenant Commander Jefferson F. Moser, U.S.N. The civilian staff on this expedition consists of Prof. Alexander Agassiz, in charge of the scientific work, who will be accompanied by his son and his personal assistants; Dr. W. McM. Woodworth and Dr. A. G. Mayer, of the Museum of Comparative Zoology, Cambridge, Mass.; Dr. H. F. Moore, chief naturalist of the *Albatross*; Mr. Charles H. Townsend, formerly naturalist, now chief of the fisheries division of the U.S. Fish Commission; Mr. A. B. Alexander, fishery expert, and Mr. H. G. Fassett, photographer, both of the U.S. Fish Commission.

Opportunity will undoubtedly be afforded for conducting a number of important collateral inquiries without detriment to the regular scientific work. Advantage will be taken of every chance to obtain for the National Museum specimens of the mammals, birds, insects, and other land animals of the various islands visited. A study of the aboriginal fishing methods, apparatus, and boats, and the collection of specimens of the native fishing appliances will be in charge of the fishery expert.

The Smithsonian Institution has specially requested that the Fish Commission make an effort to trace the origin of some of

the ethnological specimens brought back from the Pacific islands by the Wilkes Exploring Expedition. Commissioner Bowers has notified the Smithsonian Institution that the naval and civil attachés of the vessel will be given special instructions to be on the look-out for desirable ethnological material.

There is every reason to believe that this expedition will yield valuable scientific results, and will be creditable to the United States. It is the most important marine expedition on which the Fish Commission has embarked, and one of the most promising scientific enterprises in which the U.S. Government has ever engaged. It is a matter for congratulation that, in the activity in exploration of the seas now being exhibited by various Governments, the United States will participate under such favourable auspices and be represented by a man of science of such wide experience in deep-sea investigation as Prof. Agassiz.

## *MAGNETO-OPTIC ROTATION AND ITS EXPLANATION BY A GYROSTATIC SYSTEM.*[1]

THE action of magnetism on the propagation of light in a transparent medium has been rightly regarded as one of the most beautiful of Faraday's great scientific discoveries. Like most important discoveries it was no result of accidental observation, but was the outcome of long and patient inquiry. Guided by a conviction that (to quote his own words) "the various forms under which the forces of matter are made manifest have one common origin," he made many attempts to discover a relation between light and electricity, but for very long with negative results. Still, however, retaining a strong persuasion that his view was correct, and that some such relation must exist, he was undiscouraged, and only proceeded to search for it more strictly and carefully than ever. At last, as he himself says, he "succeeded in *magnetising and electrifying a ray of light, and in illuminating a magnetic line of force.*"

Faraday pictured the space round a magnet as permeated by what he called lines of force; these he regarded as no mere mathematical abstractions, but as having a real physical existence represented by a change of state of the medium brought about by the introduction of the magnet. That there is such a medium surrounding a magnet we take for granted. The lines of force are shown by the directions which the small elongated pieces of iron we have in iron filings take when sprinkled on a smooth horizontal surface surrounding a horizontal bar magnet, as in the experiment I here make. [*Experiment to show field of bar magnet by iron filings.*]

The arrangement of these lines of force depends upon the nature of the magnet producing them. If the magnet be of horse-shoe shape, the lines are crowded into the space between the poles; and if the pole faces be close together and have their opposed surfaces flat and parallel the lines of force pass straight across from one surface to the other in the manner shown in the diagram before you. [*Diagram of field between flat pole faces.*]

The physical existence of these lines of force was demonstrated for a number of different media by the discovery of Faraday to which I have already referred, and on which almost all the later work on the relation of magnetism to light has been founded. I am permitted by the kindness of the authorities of this Institution to exhibit here the very apparatus which Faraday himself employed, though for the various experiments I have to make it is necessary to actually use another set of instruments. [*Apparatus shown.*] Before repeating Faraday's experiment, let me describe shortly what I propose to do, and the effect to be observed.

A beam of plane polarised light is produced by passing white light from this electric lamp through a Nicol's prism. To understand the nature of plane polarised light, look for a moment at this other diagram (Fig. 1). It represents a series of particles displaced in a certain regular manner to different distances from the mean or equilibrium positions they originally had along a straight line. They are moving in the directions shown by the arrows and with velocities depending on their positions, as indicated by the lengths of the arrows. Suppose a certain interval of time to elapse. The particles will have moved in that time to the positions shown in this other diagram (Fig. 2) on the same sheet. It will be seen that the velocities as well as the positions of the particles have altered; but that the configuration is the same as would be given by the former diagram moved through a certain distance to the left.

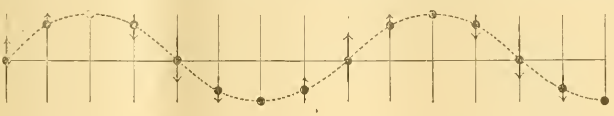


FIG. 1.

Thus an observer looking at the particles and regarding their configuration would see that configuration apparently move to the left; and this, it is very carefully to be noted, is a result of the transverse motions of the individual particles. In another interval of time equal to the former the arrangement of particles will appear to have moved a further distance of the same amount towards the left.

This transverse motion of the particles, thus shown displaced from their equilibrium positions, represents the vibration of the medium which is the vehicle of light, and the right to left motion of the configuration of particles is the wave motion resulting from that vibration. I do not say that the medium is thus made up of discrete particles, or that the different portions of it vibrate in this manner, but there is undoubtedly a directed quantity transverse to the direction in which the wave is travelling, the value of which at different points may be represented by the displacements of the particles, and which varies in the same manner, and results, as here shown, in the propagation of a wave of the quantity concerned.

FIG. 2

In fact, we have here a representation of a wave of plane polarised light. The directions of vibration are right lines parallel at all points along the wave. Ordinary light consists of vibrations the directions of which are not parallel if rectilinear, and each vibration is therefore capable of being resolved into two in directions at right angles to one another. The Nicol's prism, in fact, splits a wave of ordinary unpolarised light into two waves, one in which the vibrations are in one plane containing the direction in which the light is travelling, the other in a plane containing the same direction, but at right angles to the former. One of these waves is stopped by the film of Canada balsam in the prism and thrown out of its course, while the other wave is allowed to pass on undisturbed.

If the wave thus allowed to pass by one Nicol's prism be received by another it is found that there are two positions of the latter in which the wave passes freely through the second

[1] A discourse delivered at the Royal Institution by Prof. Andrew Gray, F.R.S.

prism, and two others in which the wave is stopped. The prism can be turned from one position to another by properly placing it and then turning it round the direction of the ray. It is found that if the prism be thus turned from a position in which the light is freely transmitted we come after turning it through 90° to a position in which the light is stopped, and that if we go on turning through another angle of 90° a position is reached in which the light is again freely transmitted, and so on, the light being alternately stopped and transmitted by the second prisms in successive positions 90° apart.

The mode of passage of the wave by the Nicols when their planes are parallel, and its stoppage when the planes are crossed, are illustrated by this diagram (Fig. 3) of a vibrating cord and two slits. When the slits are parallel, the vibration

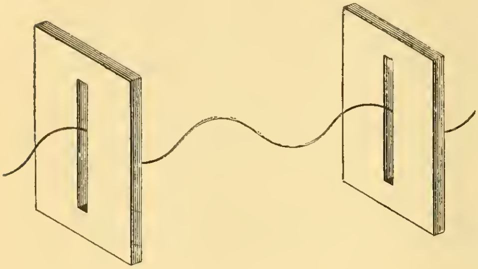


FIG. 3

which is passed by one is passed by the other; when they are crossed, a vibration passed by one is stopped by the other.

Two planes of symmetry of the prisms parallel to the ray, and called their principal planes, are parallel to one another when the light passes through both, and are perpendicular to one another when the light passed by the first is stopped by the second. We shall call the first prism the polarising prism, or the *polariser*, from its effect in producing plane polarised light; the other, the *analyser*. The stoppage of the light in the two positions 180° apart of the second prism and its passage in the two intermediate positions show that the light passed by the first prism is plane polarised.

Now a beam of plane polarised light is passed through the perforated pole-pieces of this large electro-magnet (Fig. 4), so

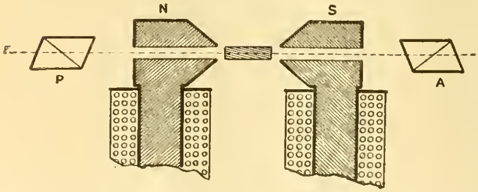



FIG. 4.

that the beam travels between the pole faces along the direction which the lines of force there would have if the magnet were excited by a current. The arrangement of the apparatus is as shown in the diagram. The light is polarised by the prism P, passes through the magnetic field, and then through the analysing prism A, to the screen. As you see, when the second prism is turned round the ray the light on the screen alternately shines out and is extinguished, and you can see also that the angle between the positions of free passage and extinction is 90°.

I now place in the path of the beam this bar of a very remarkable kind of glass, some of the properties of which were investigated by Faraday. It is a very dense kind of lead glass, which may be described as a silicated borate of lead; that is, it contains silica, boric acid and lead oxide. The beam is not disturbed although the light passes through the glass from end to end. I now adjust the analysing prism to very nearly complete extinction, and then excite the magnet. If the room is sufficiently darkened I think all will see that when the magnet is excited there is a very perceptible brightening of the dim patch of light on the screen, and that this brightening disappears when the current is removed from the magnet. This is Faraday's discovery.

How are we to describe this result? What effect has been produced by the magnetic field? It is clear that the direction of vibration of the light emerging from the specimen of heavy glass has been changed relatively to the prism so that the light now readily passes. It is found, moreover, that the amount of turning of the direction of vibration round the ray is proportional to the length of the specimen, so that the directions of vibration at different points along the wave within the specimen lie on a helically twisted surface, and may be regarded as represented by the straight rods in the model before you on the table (Fig. 5).

It is also found that the amount of the turning depends on the intensity of the magnetic field—is, in fact, simply proportional to that intensity. Hence the turning is proportional to the mean intensity of the field, and to the length of the path in the medium, that is, to the products of these two quantities. It also depends on the nature of the medium. The angle of turning produced by a field of known intensity when the ray passes through bisulphide of carbon has been very carefully measured by Lord Rayleigh, whose results are of great value for other magnetic work.

The law of proportionality of the amount of turning of the plane of polarisation to the intensity of the magnetic field in

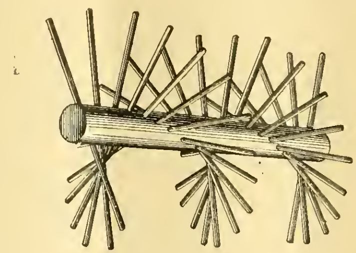


FIG. 5.

the space in which the substance is placed is not, however, to be regarded as established for strongly magnetic substances, such as iron, nickel or cobalt. The matter has not yet been completely worked out, but the turning in such cases seems to be more nearly proportional to the intensity of magnetisation, a different quantity from the intensity of the magnetic field producing the magnetisation. If this law be found correct the angle of turning will be proportional to the product of the intensity of magnetisation and to the length of the path; and the angle observed divided by this product will give another constant, which has been called Kundt's constant.

The rotation of the plane of polarisation in strongly magnetised substances was investigated by Kundt, the very eminent head of the Physical Laboratory of the University of Berlin, who died only a year or two ago. Kundt is remembered for many beautiful methods which he introduced into quantitative physical work; but no work he did was more remarkable than that which he performed in magneto-optic rotation when he succeeded in passing a beam of plane polarised light through plates of iron, nickel and cobalt. Such substances, though apparently opaque to light, are not really so when obtained in plates of sufficient thinness. In sufficiently thin films all metals, so far as I know, are transparent, not merely to Röntgen rays, but to ordinary light. Kundt conceived the idea of forming such films of the strongly magnetic metals, so as to investigate their properties as regards magneto-optic rotation. He succeeded in obtaining them by electroplating platinised glass with such thin

stratums of these metals that light passed through them in sufficient quantity for observation. The rotation produced by the glass and the exceedingly thin film of platinum was determined once for all and allowed for. Kundt obtained the remarkable result that the magnetic rotatory power in iron is so great that light transmitted through a thickness of one centimetre of iron magnetised to saturation is turned through an angle of over 200,000°, that is, that light passing through a thickness of an inch of iron magnetised to saturation would have its plane of polarisation turned completely round more than a thousand times; in other words, one complete turn would be given by a film less than $\frac{1}{1000}$ of an inch in thickness. A scarcely smaller result has been found by Du Bois for cobalt, and a maximum rotation of rather less than half as much by the same experimenter for nickel.

The direction of turning in all the cases which have so far been specified—that is, Faraday's glass, bisulphide of carbon, iron, nickel and cobalt—is the same as that in which a current of electricity would have to flow round the spires of a coil of wire surrounding the specimen so as to produce the magnetic field. This we call the *positive* direction. There are, however, many substances in which the turning produced by the magnetic field is in the contrary or negative direction; for example, ferrous and ferric salts of iron, chromate and bichromate of potassium, and in fact most compound substances which are feebly magnetic.

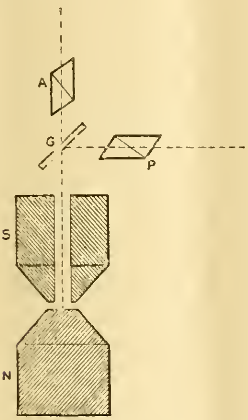



FIG. 6.

Faraday established by his experiments the fact that substances fall into two distinct classes as tested by their behaviour under the influence of magnetic force. For example, an elongated specimen of iron, nickel or cobalt, if freely suspended horizontally between the poles of our electro-magnet, would set itself with its length along the lines of force. On the other hand, a similar specimen of heavy glass, or a tube filled with bisulphide of carbon, would, if similarly suspended, set itself across the lines of force. The former substances were therefore called by Faraday paramagnetic, the latter diamagnetic.

It might be supposed that diamagnetics would show a turning effect opposed to that found in paramagnetics, but this is not the case. As we have seen, bisulphide of carbon and heavy glass, which are diamagnetics, show a turning in the same direction as that produced in iron—as indeed do most solid, fluid and gaseous diamagnetics. Feebly paramagnetic compound substances, on the other hand, produce negative rotation.

A theory of diamagnetism has been put forward in which the phenomena are explained by supposing that all substances are paramagnetic in reality, but that so-called diamagnetic bodies are less so than the air in which they are immersed when experimented on. Thus the diamagnetic quality is one of the substance relatively to air, in the same kind of way as the apparent levity of a balloon is due to the fact that its total weight has a positive value, but is less than that of the air displaced by the balloon and appendages. Lord Kelvin's dynamical explanation of magneto-optic rotation does not bear out this view of the matter.

Before passing to the dynamical explanation, however, I must very shortly call attention to some remarkable discoveries in this subject made by Dr. John Kerr, of Glasgow. I have here an electro-magnet arranged as in the diagram before you (Fig. 6). The light from the lamp is first plane polarised by the Nicol P, then it is thrown on the piece of silvered glass G, and part of it is thereby reflected through this perforated pole-piece so as to fall normally on the polished point of the other pole-piece. Reflection thus takes place at perpendicular incidence, and the reflected light is received by this second Nicol. When the magnet is unexcited the second Nicol is arranged so as to quench the reflected light. The magnet is then excited, and it is found that the light is faintly restored, showing that an effect on the polarisation of the light has been produced by the magnetisation. It is to be noticed here that the incident and reflected light is in the direction of magnetisation. We shall not pause to make this experiment. It was arranged this morning and successfully carried out; but the effect is slight, and might not be noticeable without precautions, which we have hardly time to make, to exclude all extraneous light from the screen.

It would perhaps be incorrect to say that the plane of polarisation has been rotated in this case, as it has been asserted by Righi that the light after reflection is no longer plane polarised, but that there are two components of vibration at right angles to one another, so related that the resultant vibration is not

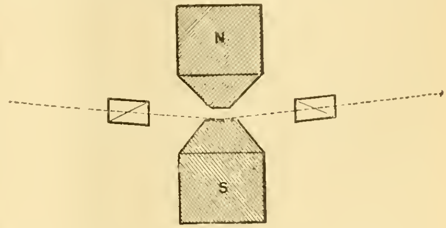



FIG. 7.

rectilinear but elliptical. There is therefore no position in which the analysing prism can be placed so as to extinguish the reflected light. The transverse component necessary to give the elliptic vibration is, however, in this case, if it exists, very small, and very nearly complete extinction of the beam can be obtained by turning the analysing prism round so as to stop the other component vibration. The angle through which the prism must be turned to effect this is the amount of the apparent rotation. The direction of rotation is reversed by reversing the magnetism of the reflecting pole. Dr. Kerr found that the direction is always that in which the current flows in the coils producing the magnetisation of the pole.

Dr. Kerr also made experiments with light obliquely incident on a pole-face, with the arrangement of apparatus shown in this other diagram (Fig. 7). He found that the previously plane polarised light was by the reflection rendered slightly elliptically polarised. A slight turning of the analysing Nicol was necessary to place it so as to stop the vibration corresponding to the long axis of the ellipse and so secure imperfect extinction.

These effects are, like those of normal incidence, very small, and they can hardly be shown to an audience.

(*To be continued.*)

## SCIENCE SCHOOLS AND CLASSES.[1]

THE annual Report of the Department of Science and Art furnishes much information on the progress made in elementary scientific instruction year by year; and the following facts, derived from the Report just published, shows the vast extent of the Department's operations during 1898. The number of students under instruction in schools eligible for the

[1] Forty-sixth Report of the Department of Science and Art of the Committee of Council on Education, with appendices. Pp. 320. (H.M. Stationery Office, 1899.)

Department's grants in that year was 158,370. These students were distributed among 11,723 classes in 2023 different schools. Scotch schools and students are not included in these figures, the Scotch Education Department having taken over the administration of grants for science and art instruction. Even more satisfactory than the increase of the number of pupils receiving science instruction is the fact that in 1898 there were 159 Schools of Science—that is, schools following an organised course of scientific instruction—in which practical work forms an essential part. The number of students in these schools was 21,193. This is a considerable increase on the preceding year, when the number of Schools of Science was 143, with 18,142 students.

For the year 1898 the grants to science schools in England, Wales and Ireland, exclusive of those made to training colleges, amounted to 169,604*l.* 3*s.* 3*d.* The sum included (*a*) 85,862*l.* to science schools for attendance grants, and 614*l.* on results of examination (honours only); total, 86,476*l.*; (*b*) 82,998*l.* to Schools of Science, for capitation and attendance grants and grants on results of examination.

The figures under (*a*) show an average payment in 1898 of 12*s.* 7½*d.* for each individual student under instruction in science schools, whilst the average payment per student under instruction in Schools of Science (*b*) was 3*l.* 18*s.* 2*d.*

The grants now made to schools are based upon the attendance of pupils, instead of being computed on the results of the individual examinations. Referring to this change and to the increase of practical work, Captain Abney, the Director for Science, says:—"In the past year, the system of payments by attendance was made general to all schools except in the case of Schools of Science. From this mode of payment candidates for honours were necessarily omitted, their work being necessarily special and requiring special treatment. The abolition of payments on results has diminished to some extent the numbers of students who were presented for examination, and the course of instruction in the various stages of the subjects of science for which payments are made will be more prolonged. This undoubtedly tends to sound instruction. . . . There is a decided increase in practical instruction in various subjects, and in many places laboratories for physics and for biological subjects have been provided, as the higher attendance grant is only attainable where such provision has been made. I cannot help commenting upon the very marked impression that the obligation to give practical instruction in science has made in the elaboration of apparatus for teaching purposes. At a conference on science teaching, held at the Chelsea Polytechnic under the auspices of the London Technical Education Board, there was an exhibition and demonstration of the use of science apparatus in teaching. The novelties in apparatus and the general interest taken in the conference by science teachers and others clearly indicated the rapid advances that had been made in this branch of teaching"

The Reports of the Inspectors of the Department include many points worthy of the consideration of educationists. The following extracts contain a few of the views expressed on the general subjects of secondary schools and science teaching; and as they represent opinions based upon direct experience of the conditions of elementary scientific instruction in this country, they have exceptional value.

*Extracts from Reports.*

Many of the smaller secondary schools are still badly equipped for teaching purposes. Most of them are ill-supplied with funds, and have consequently an inadequate and inferior staff of teachers, while some few are bent upon continuing methods and subjects of instruction which must be of little value to the class from which their pupils should be drawn. It is, moreover, impossible to deny that owing to the practical absence of outside criticism some few secondary schools are hopelessly inefficient. . . . Many country grammar schools have reason to be thankful to the County Councils for the very liberal aid they have received towards the erection or equipment of suitable rooms for science purposes, or towards the payment of a science master. The County Councils can for their part in most cases ensure that the science work is thoroughly and systematically given by requiring the school to place itself in connection with the Department. To this the best and most progressive of the smaller schools offer no objection. They realise that assistance from public funds must be accompanied by some amount of public control, and as a rule the visit of the inspector is most feared where it is most unknown. Still, in spite of County Council assistance and Department grants, many of the endowed grammar schools are still in straitened circumstances. Where fees are low and endowments small, it is often a serious matter to secure a proper staff of teachers, to keep fittings and apparatus in a proper state of completeness, and to provide for the necessary outlay on repairs, rates and taxes. It is therefore not a matter for surprise if the science and art appliances in some of the secondary schools are found to be meagre in quantity and poor in quality.

On the whole, it may be said that a very fair provision has been made for scientific and technical instruction of the youth of the country up to, at any rate, the age of sixteen or seventeen, supposing them to devote themselves to study until attaining that age, and that in most large towns the artisan and manufacturer can obtain good instruction in technology and general science. But our larger polytechnics could be much further utilised if research work in their laboratories were more encouraged.

It would be most helpful to the technical education of the country if a fairly liberal grant could be paid on any student who, having acquired sufficient training in science, devoted himself to some special work in a laboratory under the supervision of the teacher in charge. The results of such work might be examined and criticised by the professors and examiners of the Department, and, if worthy, brought to the notice of the various societies for the promotion of scientific investigation.

The freedom from examination in the elementary courses of Schools of Science has had considerable influence on the character of the teaching, especially in the practical work. Teachers have awakened to the fact that science may afford a sound mental training, and that method is no less important to a student than results. Syllabuses exhibit a more logical sequence. Instead of depending upon a course thought out by others, teachers are beginning to think out their own, and although there is room for improvement, enlightened methods are making way. The "Heuristic method," which seeks to make each boy or girl a "discoverer" of known physical laws, and thus develop in him the scientific spirit, has had an important influence on the teaching of science. In the hands of a highly competent teacher it is an important guiding principle—in the hands of some of its disciples there is danger of its becoming a fetish. The Heuristic method is essentially historical; the pupil is told little, but is put in the way of finding out for himself, which is well. But there is as much danger in telling him too little as in telling him too much. It is not perhaps impertinent to point out that scientific discoveries have seldom been inductive. Investigators have been acquainted with the results of other discoverers, and have had, almost invariably, a "working hypothesis" which they have sought to establish by deductive methods. It is therefore advisable to lay stress on the usefulness in teaching science of a "working hypothesis," which should form the basis of practical work having for its object the "discovery" of a law. Though the beginner "must be put in the position of an original discoverer," it should be borne in mind that an original discoverer has at his disposal the observations and views of other investigators. It is only fair that the student should be placed in pretty much the same position, otherwise his observations will be ill-directed, and will lead him nowhere. It is almost needless to remark that in any case the advanced work may be more didactic.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE natural history collections in the Whitechapel Public Library and Museum are being systematically used by many teachers in the elementary schools of the district to illustrate object lessons. Teachers who propose to utilise the collections for this purpose send to the curator, Miss Kate M. Hall, a list of the object lessons they are giving, and arrangements are then made for one or more practical demonstrations bearing upon the lessons. The children (about forty-five in number) are brought up to the museum every week, for 1 to 1½ hours, until the course is finished. They are divided into three groups of fifteen, and each group spends about twenty minutes at each table on which the specimens chosen for the lesson have been placed. In this way the children have the opportunity of closely observing the objects, and of comparing the structure

with that of other animals or plants. By this means the Library Commissioners are making the collection of real service in elementary education.

The Scottish Education Department has formulated a scheme whereby an agricultural college is to be instituted, to take over the functions of the agricultural department of the Glasgow and West of Scotland Technical College and the Kilmarnock Dairy School. The special grant of 2000*l.* voted for agricultural education in Scotland, and now administered by the Scotch Education Department, has been distributed in various amounts to four institutions, two being those mentioned and the two others the Edinburgh School of Rural Economy and the Agricultural Department of Aberdeen University. It has, however, long been felt that the grants to these institutions ought to be reinforced by contributions from local authorities in order to place the institutions in a position to exercise a more decided influence upon the progress of agriculture in Scotland than has yet been possible. Several County Councils having recently promised support, in some cases of a very substantial kind, to an independent agricultural college in the West of Scotland, the Scotch Education Department prepared a scheme for such an institution, and it has been accepted by the various bodies concerned. The college will give facilities for the most thorough and highly developed instruction in agriculture to those students who are able to devote a considerable time to this study, and should at the same time be a means of bringing home to the agricultural population of the districts concerned the latest results of agricultural research.

The degree of Doctor of Philosophy was conferred in 1898 upon 224 candidates by twenty-three universities in the United States. An analysis of the statistics referring to these doctorates is given in *Science*, together with the names of those who received the degree in science, and the titles of their theses. Of the 224 degrees, 72 were in the humanities (under which are included philology, grammar, literature and philosophy), 37 were in history and economics, and 115 in the sciences. Six universities, Johns Hopkins, Columbia, Yale, Chicago, Harvard and Pennsylvania, conferred 169 degrees—more than three times as many as all the other United States universities combined. Columbia gave this year decidedly the largest number of degrees in the sciences, while Harvard is the only one of these universities in which the degrees in the humanities were more numerous than in the sciences. The distribution of students among the different sciences was as follows:—Chemistry, 32; psychology, 15; mathematics, 13; botany, 11; zoology, 11; physics, 7; education, 5; geology, 5; sociology, 5; palæontology, 4; astronomy, 2; mineralogy, 2; physiology, 1; bacteriology, 1; meteorology, 1. It will be noticed that chemistry leads very decidedly. While no definite conclusion can be drawn from the results, it may be noted that at Johns Hopkins more than half the scientific degrees are given in chemistry. This science also leads at Yale and Harvard. Psychology and education are especially strong at Columbia. Chicago stands first in zoology and in physiology.

The Technical Instruction Committee of the Oxfordshire County Council have presented their annual report on the work of the schools and institutions aided by them during the past year. The Committee has been recognised by the Department of Science and Art as the organisation responsible for science and art instruction within its area. No grants will therefore be made by the Department to the managers of new schools and classes unless they are acting in unison with the Committee. The managers of all the schools and classes in the county which are receiving Science and Art grants have agreed to come within the new organisation. With regard to rural agricultural instruction, the Committee report that at the Chipping Norton Agriculture Class, under Mr. W. Warne, there were seventy-six students, of an average age of 39·5. They were factory hands, labourers, mechanics and small tradesmen, who all cultivated allotments. One thousand and twenty attendances were made at twenty-four meetings. The subject of the course was "Insects as friends and foes to agriculture." To illustrate how agriculture is being gradually develcped by the work of the science lecturers, the Committee report that from advice given by Mr. Stewart, at Minster Lovell, in his lectures, an acre of strawberries was planted. This year a much larger area was laid down there. It is hoped that an industry in soft fruit is now started in that locality. At the same place a fruit farm of three acres was laid out two years ago on Mr. Stewart's advice. It was so successful that now twelve acres are laid out. At Stoke Row, eight tons of filberts last year were saved by the treatment given to the nut weevil, and last year the currant bushes were afflicted by the currant mite, but spraying the bushes enabled four tons to be marketed. Codlin moth and apple-blossom weevil attacked the apple trees, but Mr. Stewart's treatment saved the trees. When agriculturists are brought in this way to see the practical side of scientific knowledge they begin to understand the value of the science of agriculture.

## SCIENTIFIC SERIALS.

*American Journal of Science*, July.—Velocity of electric waves in air, by G. V. Maclean. The author describes an elementary type of coherer suitable for the Hertzian experiment of determining wave-lengths from nodes produced by metallic reflection. It consists of two globules of platinum, 1 mm. in diameter, attached to the ends of two platinum wires forming spirals about two iron terminals which run through the centre of the two brass caps of a glass tube 8·5 cm. long. The globules can be adjusted to any small distance from each other. The velocity of propagation, determined from the wave-length and the period of oscillation, is $2{\cdot}991 \times 10^{10}$ cm. per second, or practically the same as along wires.—Spiral fulgurite from Wisconsin, by W. H. Hobbs. A lightning tube forming a perfect dextrorotary helix has recently been presented to the geological collection of the University of Wisconsin. It was found embedded in a sand knoll about ten feet high, at a distance of five feet below the surface. The tube is as thick as a man's thumb, and five inches long. The fulgurite from Waterville, Maine, described by Bayley in 1892, also shows a dextrorotary structure. The author suggests that this twist is somehow connected with the electrical conditions under which the tubes were produced, and guesses at an influence of the earth's magnetic field upon the path of the lightning.—The mouth of Grand River, by E. H. Mudge. The mouth dealt with is not the present Grand Haven, but another point seventy miles inland from the shores of Lake Michigan, which was the termination of the old river valley. At one time a great glacial stream, three-fourths of a mile in width, flowed across the peninsula from Lake Saginaw to Lake Chicago. This stream has been called the Pewamo outlet. The author describes its course and the river-mouth deposits about the old mouth.—Electrical measurements, by H. A. Rowland and T. D. Penniman. The authors have tested six out of the thirty different methods of measuring self-induction and capacity indicated by Rowland. The methods for the comparison of the two self-inductions, or a self-induction and a capacity, are independent of the period of the alternating current used, and an accuracy of 1 in 10,000 can be attained.—Reflection of Hertzian waves at the ends of parallel wires, by L. de Forest. The author uses a compromise between the Lecher and the Blondlot wire systems, and investigates the relation between the change of phase in reflection from bare ends of various shapes, and the frequency.

*Wiedemann's Annalen der Physik und Chemie*, No. 6.—Observation of fringes in the development of Daguerre plates with wedge-shaped silver iodide layers, by O. Wiener. A silver plate was iodised in two wedge-shaped layers by laying it on a glass tube during exposure to the iodine vapour, the layer thus being made to increase in thickness from the line of contact outwards. A spectrum with the slit normal to the lines of equal thickness was then photographed on the plate, and it was found that the sensitiveness varied periodically with the thickness, maxima occurring whenever the surface coincided with a ventral segment of the electrical force, produced by reflection at the boundary dividing the iodide from the metallic silver.—Experiments on certain flow formations, by K. Mack. Deals with the deformations of fungoid flow structures by gravitation, and the deformation of horizontal layers of liquid by ascending fungoid structures.—Influence of gaseous pressure upon electric currents due to Röntgen rays, by W. Hillers. Near the pressure at which the gaseous resistance reaches a maximum, the current intensity varies as the square root of the pressure.—An electrolytic current interrupter, by A. Wehnelt. This is a reprint of the author's original paper from the *Elektrotechnische Zeitschrift*.—Action of the Wehnelt interrupter, by H. T. Simon. The author formulates what he claims to be a complete mathematical

theory of the Wehnelt interrupter. Between the period T and the E.M.F. E he obtains the relation

$$T = A + \frac{B}{E^2}$$

which is closely borne out by experiment.—Magnetic properties of the elements, by S. Meyer. The author attempts to connect the permeabilities of the elements in the pure state with their atomic weight. When arranged in periodic series, the paramagnetic elements are seen to group themselves in the centre, and the diamagnetic elements at the ends. The scheme is at present very rough, owing to the difficulty of determining the permeabilities of the rare elements —Transverse tones of caoutchouc threads, by V. von Lang. When caoutchouc threads are stretched, the pitch of the note emitted by them remains constant between certain lengths, owing to the fact that the ratio of length to tension is constant. The author investigates how far Taylor's formula applies to such threads.—Accurate control of the frequency of an alternating current, by J. Zenneck. The alternate current is made to produce a rotary field, to which the kathode beam in a Braun tube is exposed. The end of the beam describes a circle on the screen, which is interrupted by a tuning-fork twice during every revolution. As long as the dots thus produced are on the same diameter the frequency is constant.

## *SOCIETIES AND ACADEMIES.*

### PARIS.

**Academy of Sciences**, August 7.—M. Maurice Lévy in the chair.—On rolling motion; equations of motion analogous to those of Lagrange, by M. Appell. The Lagrange equations cannot be applied without modification to those dynamical problems in which the relations between the solid bodies are such that they are allowed to roll or are pivoted on each other. In a system of three independent parameters $q_1$, $q_2$, $q_3$, the equations of motion are reduced to the form $\frac{\partial S}{\partial q_1} = Q_1$, where $Q_1$ is a function of the forces to which the bodies are submitted, and $S = \frac{1}{2}\Sigma m J^2$, J being the acceleration of the point *m*.—Thermochemical determinations: ethylenediamine, by M. Berthelot. Measurements are given for the heats of combustion and formation of cholalic acid, amygdalin, conicine, and ethylenediamine.—On ammoniacal silver nitrate, by MM. Berthelot and Delépine. A thermochemical study of the action of ammonia solution upon a solution of silver nitrate. The oxide of silver-ammonium is shown to be an alkali, with a heat of neutralisation comparable with those of the most energetic mineral alkalis.—On the expansion of iron and steel at high temperatures, by M. H. Le Chatelier. The table of expansions given for soft iron and six specimens of steel, at temperatures ranging between 0° and 700°, shows that the differences in the expansions of the various specimens are within the limits of experimental error; up to about 750°, iron and steel expand similarly. But above the temperature of molecular transformation the expansion of the different specimens of steel varies very rapidly with the amount of carbon present, an increase of carbon from 0·05 to 1·2 per cent. doubling the coefficient of expansion.—Action of chlorine on a mixture of silicon, silica, and aluminium, by M. Émile Vigouroux. A good yield of pure silicon tetrachloride may be obtained by first heating together a mixture of silica (200 gr.) and aluminium (100 gr.) to a dull red heat, cooling the mass and extracting with acids. The residue, thus freed from aluminium, contains from 14 to 22 per cent. of silicon, and readily gives the pure tetrachloride on treating with chlorine in the usual way.—Action of hydrogen phosphide upon copper oxide, hydrate and carbonate, by M. E. Rubénovitch. The reaction with the oxide is energetic, and takes place according to the equation

$$5PH_3 + 10CuO = 2P_2Cu_5 + H_3PO_4 + 6H_2O.$$

Copper hydrate behaves similarly, if the gas is admitted in such small quantities that the temperature of the reaction cannot rise to incandescence. With basic copper carbonate the reaction is

$$5PH_3 + 5CuCO_3.Cu(OH)_2 = 2Cu_5P_2 + H_3PO_4 + 5CO_2 + 11H_2O.$$

—On the estimation of mannose in admixture with other sugars, by MM. Em. Bourquelot and H. Hérissey. The authors apply the property possessed by mannose of giving an insoluble hydrazone in the cold to the estimation of this sugar. The numerous test analyses, some on pure mannose, others on mixtures of the same with galactose and maltose, are very satisfactory.—On some properties of dioxyacetone in respect to its molecular aggregation, by M. Gabriel Bertrand. Dioxyacetone appears to exist in two forms, one in crystals, having a molecular weight $2(C_3H_6O_3)$, which is practically insoluble in cold alcohol, ether, or acetone; the other, formed by simply melting the crystals, has the simple formula $C_3H_6O_3$, and is very soluble in these solvents. Water slowly dissociates the bimolecular form, but not so rapidly as to prevent cryoscopic measurements being made in confirmation of the above views.—On the variations in the production of glycerol during the alcoholic fermentation of sugar, by M. J. Laborde. In the numerous experimental results quoted, the glycerol found varied from 2·5 to 2·75 grams of glycerine per 100 grams of sugar decomposed. The same yeast, living in saccharine media of the same concentration of sugar, may give very varying amounts of glycerol, the production being in inverse proportion to the activity of the yeast. A rise of temperature favours an increase in the amount of glycerol.—On the anatomical structure of *Vanilla aphylla*, by M. Édouard Heckel. A comparison of the anatomical characters of the stems of *V. aphylla* and *V. phalaenopsis* shows such great differences that it is impossible to class them together in the same genus. The author also points out that the theory adopted by Herbert Spencer, in his "Principles of Biology," to explain the formation of monocotyledonous stems, is strongly supported by the fact of the simultaneous presence in the stem of *V. aphylla* and the leaves of *V. phalaenopsis* of the same cellular elements constituting the skin.—The *Piralahy*, the india-rubber weed of Madagascar, by M. Henri Jumelle.—On the external border of the Briançonnais between Freyssinières and Vars, by MM. W. Kilian and E. Haug.—On the pot-holes of the granitic islets of the cataract of Assouan, by M. Jean Brunhes.

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THURSDAY, AUGUST 24, 1899.

## THE BOOK OF THE DEAD.

*The Book of the Dead. Facsimiles of the Papyri of Hunefer, Ånhai, Kerāsher and Netchemet, with Supplementary Text from the Papyrus of Nu, with Transcripts, Translations, &c.* By E. A. Wallis Budge, M.A., Litt.D., D.Lit., Keeper of the Egyptian and Assyrian Antiquities, British Museum. Pp. xi + 64 (fol.) + 98 plates. Printed by order of the Trustees. (London, 1899.)

SINCE the beginning of the present century the "Book of the Dead" has occupied the attention of the learned world, and has been a subject of study among all those who take an interest in the religious beliefs of the ancient races of mankind. The earliest publications on the subject took the form of somewhat inaccurate reproductions of papyri on which the text of the "Book of the Dead" was written; and, though much speculation existed as to the nature of its contents, it was not until well on in the present century that the foundations were laid for its correct interpretation. Champollion had made careful studies of the whole of the texts of the "Book of the Dead" to which he had access; and, from the translations of detached passages which are found scattered in his writings, it is clear that he recognised the general character of the composition. But he never translated a section of any length, and the fact that he termed the "Book of the Dead" "le Rituel Funéraire" of the Egyptians showed that he had not correctly grasped its aim and object. More than thirty years later De Rougé adopted Champollion's title for the work, but since that time it has come to be recognised by all that the composition is not a collection of ritual texts, and that a more general phrase such as "Book of the Dead" is a more suitable title for the work.

The title "Book of the Dead" may be traced to Lepsius, who in 1842, under the heading "Das Todtenbuch der Aegypter" published the text of a papyrus at Turin, which contained one hundred and sixty-five sections or chapters of the work. The ancient Egyptians themselves did not number these chapters, and no two papyri contain exactly the same chapters, nor are they always arranged in the same order. Lepsius, however, numbered the chapters as he found them in his papyrus, and though the text he published does not belong to the best period of the development of the "Book of the Dead," his numbering of the chapters has been retained in subsequent editions of the work. It was retained by M. Naville in his great work on the papyri of the eighteenth to the twentieth dynasties, which was published in 1886; and it has also been retained in the recent important publications issued by the Trustees of the British Museum.

In order to indicate clearly the importance of the volume before us, it will be necessary to give a brief account of what the "Book of the Dead" is. It consists of a collection of chapters or separate compositions of different lengths, which are found in Egypt inscribed upon pyramids, upon the walls of tombs, upon sarcophagi, and coffins, and amulets that were buried with the dead; it is also found written upon long rolls of papyri which were placed in the tomb with the deceased. Stated briefly, the object of all these compositions was to ensure the preservation of the dead man's body and to secure his welfare in the world beyond the grave. Dr. Wallis Budge has recently put forward a theory as to the process by which such powers became ascribed to this collection of compositions, which are conveniently classed together as the "Book of the Dead." He has pointed out that in the earliest period of Egyptian civilisation the dwellers on the Nile, as is evident from recent excavations, were in the habit of carefully preserving the dead bodies of their friends and relatives. Even at this early period it is clear that the Egyptian hoped to live a life after death, and that the life he looked forward to he imagined would be very similar to that he lived on earth; and it is also clear that to attain this future life he believed that it was absolutely necessary to preserve his body from decay. The earliest graves in Egypt show that the Egyptians of that period, like their descendants of later date, endeavoured to attain to the future life by the embalming of the body. The recently excavated prehistoric graves, in which, along with flints, bronze implements and pottery, the skeletons of human bodies have been found lying on their sides with their knees bent up on a level with the chest, furnish evidence that even at the dawn of history the inhabitants of Egypt embalmed their dead; for many of the bones found in the graves show traces that the bodies to which they belonged had been treated with substances used in embalming. But it was clear to the ancient Egyptian that bodies, even when embalmed, were accessible to the attacks of foes and to the ravages of wild beasts. And so, in course of time, men raised pyramids about the dead to protect them, or buried them in chambers hewn out of the living rock. But the most carefully constructed tomb could not wholly prevent decay, and there was always danger of damp getting to the tomb, or of the body falling to pieces from dry-rot. According to Dr. Budge's theory, the Egyptian now called in some other power besides his own to prevent the destruction of the body, and, while he still continued to embalm his dead, he assigned to the priest the task of finding some means by which decay might be prevented. To attain this end the priest pronounced certain words and formulæ over the body. These formulæ, Dr. Budge considers, formed the foundation of the "Book of the Dead" of later times. As was but natural, they gradually increased in number and complexity, and developed with the changing civilisation of the race; with them were incorporated beliefs belonging to various periods in the long course of Egyptian history, and opinions held by quite different schools of thought. But the object of all these various compositions was the same, namely, to benefit the deceased man beyond the grave. They were intended to give him all he would want in the future life, they would ensure him victory over his foes, and they would enable him to safely reach the abode of the blessed, where he hoped to live happily in the future.

The importance of a careful and comparative study of these numerous forms of the "Book of the Dead" for a

right understanding of the religion of the ancient Egyptians is obvious, and the first step towards such a comparative study is to acquire all texts available for the purpose and to make them accessible to the numerous students, who in England, and on the continent, and in America are now devoting so much time and labour to the comparative study of religion. For many years the Trustees of the British Museum have had this object in view, and they have issued a most important series of facsimiles and works dealing with the "Book of the Dead"; the series was begun under the editorship of the late Dr. Birch, and has recently been continued under that of Dr. Wallis Budge, who has succeeded him in the keepership of the Egyptian and Assyrian antiquities at Bloomsbury. Of these publications, the "Egyptian Texts from the earliest period from the Coffin of Āmamu," which were published in facsimile with a translation by Dr. Birch, belong to the recension of the "Book of the Dead" which is found written upon coffins during the eleventh and twelfth dynasties; while the "Photographs of the Papyrus of Nebseni" placed in the hands of scholars one of the finest and most complete texts of the Theban recension of the work then known. In the year 1888 Dr. Wallis Budge, while in Egypt, acquired for the Trustees the famous Papyrus of Ani, which, dating from the second half of the eighteenth dynasty, is the most perfect and best illuminated of all papyri of the "Book of the Dead." Two years after its discovery it was published in facsimile, and in 1895 a second edition of the facsimile was issued, together with a translation and introduction from the pen of Dr. Budge. The texts thus published illustrate the history of the "Book of the Dead" in the period which lies between B.C. 2600 and B.C. 1700.

The volume just issued by the Trustees supplements these previous publications. It is larger than any of its predecessors, giving facsimiles, transcripts, translations, &c., of no less than five complete papyri of the "Book of the Dead," including a copy of the "Book of Breathings," a late form of composition to which the "Book of the Dead" was eventually reduced. These documents are all fine examples of the work, and they date from the beginning of the eighteenth dynasty to the end of the Ptolemaic period, that is, from about B.C. 1650 to B.C. 100. The series of publications on the "Book of the Dead," that has been issued by the Trustees at intervals during the last thirty-three years is therefore now complete.

In describing the contents of the volume it will not be possible within the limits of this review to do more than indicate roughly the general characteristics of the various papyri and the bearings each one has on the problems connected with the history and development of the great funereal work of the Egyptians. The first papyrus in the volume is that of Hunefer, an overseer of the palace and superintendent of the royal cattle, and "royal scribe" in the service of Seti I., King of Egypt about B.C. 1370. It is not a very long papyrus, but its vignettes are singularly beautiful. No other papyrus of the nineteenth dynasty is so finely illustrated, and as an artistic work it may be said to rank very little below the Papyrus of Ani. Perhaps the most interesting of the larger vignettes is the scene before the tomb on Plate 7. By the door of the tomb is set the sepulchral tablet of the deceased, and in front is seen the mummy of Hunefer, supported by the jackal-headed Anubis, one of the chief gods of the dead, who presided over the embalming of the mummy and accompanied the deceased into the presence of Osiris. Hunefer's wife and daughter kneel weeping at the mummy's feet, while behind are three priests performing ceremonies for the dead man's benefit and burning incense. Of the smaller vignettes the most interesting is the one at the very end of the papyrus, attached to Chapter xvii. (Plate 11); the vignette represents a cat, in front of the Persea tree, cutting off the head of a serpent, and symbolises the rising sun-god slaying the dragon of darkness—a legend that finds a place in the mythology of many other races.

The second papyrus in the volume is that of a lady named Ȧnhai, who was attached to the college of Ȧmen-Rā at Thebes, and who lived at the end of the twentieth or at the beginning of the twenty-first dynasty, *i.e.* about B.C. 1100. The vignettes are of an unusual character, and show that under the influence of the priests of Ȧmen the "Book of the Dead" was illustrated with scenes which do not belong to it by right, but are drawn from other works dealing with the Underworld. Of the vignettes an interesting one (Plate 6) shows the lady Ȧnhai binding up bundles of wheat and performing other duties in the Elysian fields. Another vignette represents the creation of the universe (Plate 8), and is an interesting variant to the similar scene depicted on the sarcophagus of Seti I. The third papyrus is that of Netchemet, who was in all probability the daughter of the priest king Ḥer-Ḥeru-sa-Ȧmen, who ruled over Egypt about B.C. 1000. This papyrus is inscribed in hieratic, and as it has not the beauty of colouring of the two first papyri in the volume, it has been reproduced in a series of half-tone blocks. The papyrus of Kerāsher, the fourth in the volume, is inscribed with a copy of the "Book of Breathings," a late form of the "Book of the Dead," dating from the late Ptolemaic or Roman period.

So far as the text of the "Book of the Dead" is concerned, by far the most valuable of the five papyri is the last in the volume, for it contains a number of chapters that have not hitherto been found in the Theban Recension, in addition to a good deal of rarely-found as well as quite new material. Nu was an officer in the house of the overseer of the Chancery, and the son of Ȧmen-hetep, and the papyrus dates from about B.C. 1650. It is the oldest illustrated copy of the "Book of the Dead" that is known.

We have only been able to give the briefest sketch of the contents of this very valuable book, but what we have said will suffice to indicate its importance, inasmuch as it presents a mass of new material for the study of the ancient Egyptian religion. Moreover, two out of the five papyri are written in the hieratic character, which of course is a sealed script to all but a few experts. Dr. Budge, however, has furnished them with transcripts into hieroglyphics, so that the book may be used as a chrestomathy by those who would acquire a knowledge of this interesting but difficult form of Egyptian writing. Of the value and interest of Dr. Budge's introductions and translations, appended to the various papyri, it is unnecessary to speak at length, for even before the publication of this work

no other living scholar had done more than he for the study of the "Book of the Dead," both by the publication of new material and by the interpretation and translation of the entire work. The present volume is unique in its own sphere, and no private individual or firm of publishers could have undertaken the responsibility of such a production. The Trustees have earned the gratitude of scholars by making so much new material available for general study, and they are to be congratulated on the production of a monumental work which worthily carries on the scholarly traditions attaching to the Museum at Bloomsbury.

## HAMILTON'S QUATERNIONS.

*Elements of Quaternions.* By the late Sir W. R. Hamilton. Second edition. Vol. I. Edited by C. J. Joly. Pp. xxxiii + 583. (London: Longmans, Green, and Co., 1899.)

FOR many years Hamilton's "Lectures" and "Elements" have been out of print, and the ardent student of quaternions was oftentimes unable to secure a copy of either of these great classics. Prof. Tait's treatise on quaternions is probably a better introduction for the beginner, who is more quickly brought into touch with the essential spirit of the method than he would be in Hamilton's pages. But he must, some time or other—unless he be a second Hamilton—bathe his mathematical being in the inexhaustible streams of quaternion analysis and symbolism that flow from the great master's mind. A second edition of Hamilton's immortal work is therefore to be warmly welcomed. English-speaking students will now be able to study Hamilton freely without having recourse to French or German translations; and it is our hope that the issue of this second edition will lead to a wider appreciation of the value of quaternions as a mathematical method peculiarly adapted to the geometry of space and general problems in dynamics.

The new edition is printed by direction of the Board of Trinity College, Dublin, and is edited by Prof. Joly. In the larger size of page and larger and wider type there is a great improvement on the original form, although it has necessitated dividing the book into two volumes. The small print has been done away with altogether. This, in itself, no doubt is better for the reader; but the advantage is lost that he can no longer discern at a glance what is illustration and particular from what is general and fundamental. For example, in the very important sections on the linear and vector function, one of the most beautiful of Hamilton's creations, the reader cannot pick out so readily as in the original edition the broad line along which the fundamental properties of this function are developed. Many of the illustrations are really of the character of examples, such as Prof. Tait puts at the end of his different chapters. Printing these in the same style as the more important parts tends to give them a fictitious value, and to blurr the whole perspective of the book.

The editor has added occasional notes to elucidate points which might appear obscure to the student. In some of these a different line of proof may be suggested, or they may simply amount to a reference to another section. Prof. Joly has exercised this editorial function with judgment. One of the longest of these notes is appended to the chapter on the well-known $i, j, k$ relations, and brings out clearly the necessity for the negative sign of the square of a vector, *if the associative law in products is to hold.* The system which is built on the assumption that $i^2=j^2=k^2=+1$ is ascribed to Mr. Oliver Heaviside. It ought, strictly speaking, to be ascribed to O'Brien, a contemporary of Hamilton's.

We are not called upon at this date to consider the merits of Hamilton's great calculus. The objections taken to it by mathematicians great and small have been so curious and, in some cases, so puerile that we doubt if these critics have ever seriously set themselves to study its true character. One really eminent mathematician who had been fortunate enough to pick up a copy of Hamilton's "Lectures" for a trifling sum, gladly transferred his prize next day to a friend, remarking that the man must have been mad who invented quaternions, for he made two sides of a triangle equal to the third side! Maxwell adopted the compact suggestive notation in his "Electricity and Magnetism"; and many of the transformations which are so necessary now-a-days in connection with electromagnetic waves, and take a page or two to effect in ordinary notation, are done almost by inspection by quaternion methods. Maxwell did not use the quaternion method, not because he regarded it as inferior to the notation, as one writer has with curious logic argued, but simply because the world was not ready for it. Let us hope that with this handsome re-issue of one of the most characteristic works of our century a renewed interest will be taken in the study of quaternions, so that in the near future operations and notations alike may be freely used in works on mathematical physics. Prof. Joly deserves the gratitude of all for his labour of love. When we remember the peculiar characteristics of Hamilton's style, with its redundant italics and capitals, we realise the hardness of the task the editor has set himself in reproducing to the letter (barring misprints) this great monumental work.

One word in conclusion. Is no new edition of the "Lectures" to be brought out—or at any rate of Lecture vii., which is nearly as long as the other six put together? A re-issue of Lecture vii., with perhaps an introductory chapter giving the fundamental principles of the calculus, would confer a boon on many students. In this so-called "Lecture," the great mathematician moves with a giant stride over the greater part of the whole field of geometry and dynamics. From it alone Tait drew his inspiration.

C. G. K.

## OUR BOOK SHELF.

*A Short History of the Progress of Scientific Chemistry in our own Times.* By Prof. W. A. Tilden. Pp. x + 276. (London: Longmans, Green, and Co., 1899.)

IN size and scope Prof. Tilden's short history recalls Wurtz' brilliant little "History of Chemical Theory," published thirty years ago. But whereas the key-note of Wurtz' book was the "immortal memory" of Lavoisier, and its main theme the vindication of French chemists *contra mundum*, the spirit of Dr. Tilden's book lies in its impartiality and sound judgment. In mode of

treatment, too, the authors differ. Wurtz, with more personal touches and controversial points, traces the main ideas of chemical combination from the time of Lavoisier continuously to his own; Prof. Tilden, adopting the more natural lecture method, has given us separate histories of the main lines of chemical progress during the Victorian era. We cannot doubt but that the student will find the modern book handier to consult, and sounder, though possibly less stimulating, than its predecessor.

The difficult task of selection has been, on the whole, successfully met by Prof. Tilden. We can heartily commend for its lucid treatment the chapter on stereochemistry, and "the classification of the elements" for its historical completeness and common sense.

The few slips we have observed are mainly printer's errors, *e.g.* the date of the "Sceptical Chymist" is given as 1680 (p. 38). In the account of Dumas' experiments on the composition of water, we are told that the retention of hydrogen by the reduced copper was unsuspected in Dumas' time (p. 80); but Dumas himself refers to this error in his original paper. Prof. Tilden repeats the usual derivation of gas, "Gas = geist = spirit." But since the publication of "Gas" in Dr. Murray's Dictionary we thought the derivation from chaos had been accepted. Perhaps we may quote the full passage from Van Helmont, which occurs in the "Progymnasma Meteori" (p. 69, ed. 1682): "Verum quia aqua in vaporem, per frigus delata, alterius sortis, quam vapor per calorem suscitatus; ideo paradoxi licentia, in nominis egestate, halitum illum gas vocavi non longe a Chao veterum secretum."

*La Géologie Expérimentale.* Par Stanilas Meunier, Professeur de Géologie au Muséum d'histoire naturelle de Paris. Avec 56 figures dans le texte. Pp. 306. (Paris: Félix Alcan, 1899.)

IN this work, which has just been added to the "Bibliothèque Scientifique Internationale," Prof. Meunier has aimed at supplying a complete and practical series of experimental illustrations of as many different geological phenomena as possible — in this respect going even farther than did the late M. Daubrée in his classical "Études Synthétiques de Géologie Expérimentale." The work is founded on a course of lectures given in Natural History Museum of Paris in 1898; and in the Geological Gallery of the Museum in the Jardin des Plantes may be seen the actual apparatus, designed by the author and others, for carrying on the experiments described in these pages.

After a general introduction on the value and limits of the experimental method as applied to geological teaching and research, in which the author replies very effectively to the objections which have been raised to it, he proceeds to treat systematically with the questions involved in supplying experimental illustrations of geological phenomena. He first deals with the results produced by the action of external forces operating on the earth's crust. These are classed as the phenomena of denudation and of sedimentation. Under the first head are classed the action of rain, of rivers, of the sea and lakes, of ice, of subterranean waters and of the wind. It is noticeable that the experiments, many of which are of a novel character, are for the most part such as can be performed with very simple apparatus, of a kind which any ingenious lecturer may readily provide himself with at a relatively small cost, and the experiments are certainly calculated to give point and value to the teaching they are intended to illustrate. The various kinds of sedimentation are treated of in the same way, the action of rain, rivers, seas and lakes, subterranean waters and wind in accumulating materials to form new rocks being successively handled. In the second part of the work we have a series of experiments to illustrate the action of the internal forces at work on the earth's crust. The origin of crystalline rocks, including illustrations of vitrification and devitrification, metamorphism, both contact and regional, and the origin of mineral veins are discussed in a somewhat summary manner, with reference chiefly to work that has been carried on in France; and this division of the book ends with a rather speculative chapter on the more deeply-seated materials of the globe. The third part of the work deals with volcanoes, earthquakes and the production of mountain-chains. Although the treatment of the various questions is—perhaps necessarily—somewhat unequal, no teacher of geology can fail to gather from this work of Prof. Meunier many useful hints which will prove of great value in illustrating the action of the various forces which have contributed to the production of the features of the earth's crust, while the student and general reader will find it equally full of suggestiveness and novelty.

*The Fauna of Shropshire: being an Account of all the Mammals, Birds, Reptiles and Fishes found in the County of Salop.* By H. E. Forrest. Pp. viii + 248 + vi; illustrated. (Shrewsbury and London, 1899).

THIS little book, excellent in its way as a local vertebrate fauna, is somewhat more than its title implies. It gives, for instance, a very well-written and interesting account of the habits of many species of British mammals, more especially the smaller and commoner kinds. Particular attention may be directed to the life-histories of the mole and the shrew, some of the facts in the former being new to us. The great feature of the book is the very excellent account of the mode of development and general habits of the British Amphibia; this group of animals being apparently the author's favourite subject of study. The reptiles are treated nearly as fully as the frogs and newts; and here we may notice that the author considers that the legend of the viper's swallowing its young may prove to be based on fact. A much smaller proportionate amount of space is devoted to the birds, for the reason that the author hopes to elaborate this portion of his subject on a future occasion.

Although the illustrations, which are chiefly taken from mounted groups, are less satisfactory than they might be, the work may be commended not only to the naturalists of Salop, but to those of the British Islands generally.

R. L.

*La Pratique du Maltage.* Par Lucien Lévy. Pp. 248. (Paris: G. Carré et C. Naud, 1899.)

THIS work, which may be classed as belonging to the best type of modern technical literature, is based on a series of lectures given by Prof. Levy at the "Institut des Fermentations de l'Université Nouvelle" of Brussels. At present there is a very open field for such a book, for during recent years no other work devoted specially to malting has been published which attempts, like the one before us, to combine the scientific and practical sides of the question. The work will have most value to readers in this country for the very complete account it contains of recent scientific work connected with germination; this is given in a very clear and concise form, and the most recent researches of any importance are referred to. The more technical portions of the book bear a continental stamp, and in certain places lead us to think that there are some things connected with malting we do better in England. However this may be, the work as a whole is recommended to those interested in malting as the best technical treatise on the subject at present published; but it should be borne in mind that it is specially

written for students on the continent, where the method of malting differs somewhat from ours. The printing, paper, and binding of the book are particularly good.

A. J. B.

*Curiosities of Light and Sight.* By Shelford Bidwell, M.A., LL.B., F.R.S. Pp. xii + 226. (London: Swan Sonnenschein and Co., Ltd., 1899.)

MANY readers will be glad to possess this collection of essays, in which Mr. Shelford Bidwell describes some of the experiments which the scientific world owes to his ingenuity. The five chapters in the volume are based upon notes of lectures delivered to various audiences; and their subjects are: light and the eye, colour and its perception, some optical defects of the eye, some optical delusions, and curiosities of vision. Each subject is presented with freshness of style, and elucidated by many simple and convincing experiments. To the popular lecturer on science, who desires to know how to produce curious and instructive optical effects, the volume will be very acceptable, and every physical experimentalist may confidently turn to it for inspiration. But though the curiosities of colour phenomena, and of sight generally, are chiefly described in the book, many questions of deep interest to students of both physical and physiological optics are discussed, so that the volume appeals to scientific as well as popular readers.

## LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### A Curious Salamander.

THE artificial propagation of food fishes is an important part of the work of the United States Fish Commission, and for this purpose it has a number of hatcheries or "stations" scattered throughout the Union. At each of these stations especial attention is given to the rearing of the fishes best adapted to the region in which that particular station is placed, as it would be useless to breed salmon or trout for the warm, sluggish streams of the South, or to put bass and carp into the cold, swift rivers of New England or of Michigan. The sea stations are devoted to the study of marine zoology, and the propagation of shad, mackerel, cod, lobsters and similar organisms that cannot be bred in fresh water; while hatcheries have been put on the banks of several lakes at which whitefish, land-locked salmon, lake trout and the like are reared.

A few years ago a station was established near the town of San Marcos, Texas, for the culture of black bass and "crappies." A prime essential for fish hatching is a copious supply of water, and the supply should be as uniform in amount, temperature and composition as it is possible to obtain. If there be much sediment in the water, it will be deposited on the eggs and suffocate them; and sudden variations in temperature may also be fatal. As the rainfall in western Texas is untrustworthy, the Commission determined to bore an artesian well to supply the water for its new station.

The well was bored successfully and a flow of twelve-hundred gallons per minute obtained from a depth of 188 feet. There are several such wells in this region that give this amount or more, but soon after the San Marcos well was opened a number of living animals began coming up with the water. So far, four kinds of Crustacea and a salamander have been seen, and of these quite a number have been obtained. The Crustacea are new to science and were described by Dr. James E. Benedict, of the Smithsonian Institution. They are white and perfectly blind. Most of the shrimps and crab-like animals have eyes set on the extremities of stalks that project above the surface. The shrimps from this well have the stalks, but the eyes have disappeared.

The most remarkable creature that has come from the well is the blind salamander, the *Typhlomolge Rathbuni*. The name

FIG. 1.—*Typhlomolge Rathbuni*, seen from above. (Photographed by W. P. Hay.)

is compounded from the Greek *typhlos*, blind, and *molge*, a kind of salamander; while the second term was given in honour of Mr. Richard Rathbun, the Assistant Secretary of the Smithsonian Institution, and for many years the Chief of the Division

FIG. 2.—*Typhlomolge Rathbuni*, $\frac{3}{4}$ life. (Photographed by W. P. Hay.)

of Scientific Inquiry of the Fish Commission. This animal is a new species and a new genus. It was described by Dr. L. Stejneger, of the Smithsonian Institution. The *Typhlomolge* is from three to four and a half inches in length. It has a large head, protruding forward into a flattened snout that bears the mouth. The eyes are completely covered by the skin, and are visible from the outside only as two black specks. Just behind the head are the gills. These are external and stand out in festoons about the neck, instead of being covered by a lid as in fishes. The skin is a dingy white, and the sharp contrast between

the colourless skin and the vivid scarlet of the exposed gills makes the appearance of this subterranean visitor striking in the extreme. It has four long, slender legs, that are gruesomely human in appearance, and are supplied with feet that are startlingly hand-like. The fore feet bear four fingers or toes and the rear ones have five, and though the legs are extremely slender, they possess a considerable amount of strength. Behind, the body terminates in a flattened tail that bears a fin like that of an eel.

In April 1899, two living specimens of this strange being were shipped by mail from San Marcos to the head office of the Fish Commission in Washington. They bore the journey of nearly 1800 miles, and reached their destination in good condition. They excited great interest, and for some time after their arrival a wondering group of spectators crowded about the aquarium into which they were put. These living specimens corrected several errors that had been made from observations of the dead bodies only. The legs are used for locomotion, and the animals creep along the bottom with a peculiar movement, swinging the legs in irregular circles at each step. They climb easily over the rocks piled in the aquarium, and hide in the crevices between them. All efforts to induce them to eat have been futile, as has also been the case with blind cave fish in captivity and they are either capable of long fasts or live on infusoria in the water.

From whence do these strange creatures come? The well is sunk in limestone, and that renders it likely that there may be some great cavern or subterranean lake communicating with it, but the rock through which the hole is bored is solid, except for a single channel two feet in diameter. The fact that the water rises nearly two hundred feet shows it to be under great pressure, and altogether this well affords material for study to geologists as well as zoologists.

Washington, D.C. CHARLES MINOR BLACKFORD.

## Palæolithic Implement of Hertfordshire Conglomerate.

THE rudely-made Palæolithic implement, illustrated to half the actual size in the accompanying engraving, is probably unique in the highly intractable material from which it is made. It was found by me in May last with Palæolithic implements of flint in the Valley of the Ver, Markyate Street, near Dunstable: its weight is 1 lb. 6¼ oz.—1677 in my collection. Although rude, there is no doubt whatever as to its true nature; there is a large bulb of percussion on the plain side, as seen in the edge

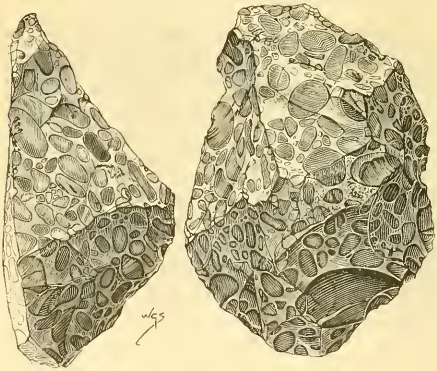


FIG. 1.—Palæolithic implement of Hertfordshire Conglomerate. One-half actual size.

view, and the hump-backed front is chipped to a rough cutting edge all round, each facet going right through the embedded pebbles. Its condition is totally different from a newly-broken block of Conglomerate, and indeed of Conglomerate broken in Roman times by quern-makers. It is faintly ochreous from being long embedded in clay, and sub-lustrous. Newly-broken Conglomerate is in colour a lustreless cold grey. The peculiar nature of the material would not admit of finer work: I have tried hard to flake Conglomerate without the slightest success; it breaks only after the heaviest blows, and then in the most erratic manner, the embedded pebbles often flying from the matrix. Sir John Evans has seen this example, and agrees with my conclusions as above expressed; he also informs me that several years ago he found what appears to be the point of a lanceolate implement of the same material and of Palæolithic character on the surface of a field near Leverstock Green.

Dunstable. WORTHINGTON G. SMITH.

## On the Calculation of Differential Coefficients from Tables Involving Differences; with an Interpolation-Formula.

(1) IN NATURE for July 20 (p. 271) Prof. Everett has given formulæ for calculating first and second differential coefficients in terms of differences. The formulæ can be more simply expressed in terms of "central differences." Let the values of a function $u_x$ be given for $x = \ldots, -2, -1, 0, 1, 2, \ldots$; then, with the usual notation,

$$\Delta u_0 = u_1 - u_0$$
$$\Delta^2 u_0 = \Delta u_1 - \Delta u_0 = u_2 - 2u_1 + u_0,$$
&c.

Now write

$$\begin{aligned} \tfrac{1}{2}(\Delta u_0 + \Delta u_{-1}) &= a_0 \\ \Delta^2 u_{-1} &= b_0 \\ \tfrac{1}{2}(\Delta^3 u_{-1} + \Delta^3 u_{-2}) &= c_0 \\ \Delta^4 u_{-2} &= d_0 \end{aligned}$$
&c.

Then $a_0, b_0, c_0, d_0, \ldots$ are the "central differences" of $u_0$. Take, for instance, the following table:—

| $y$ | $e^y$ | $\Delta$ | | | |
|---|---|---|---|---|---|
| 4·7 | 109·947 | | | | |
| | | 11563 | | | |
| 4·8 | 121·510 | | 1217 | | |
| | | 12780 | | 126 | |
| 4·9 | 134·290 | | 1343 | | 17 |
| | | 14123 | | 143 | |
| 5·0 | 148·413 | | 1486 | | 12 |
| | | 15609 | | 155 | |
| 5·1 | 164·022 | | 1641 | | 19 |
| | | 17250 | | 174 | |
| 5·2 | 181·272 | | 1815 | | 15 |
| | | 19065 | | 189 | |
| 5·3 | 200·337 | | 2004 | | 24 |
| | | 21069 | | 213 | |
| 5·4 | 221·406 | | 2217 | | 18 |
| | | 23286 | | 231 | |
| 5·5 | 244·692 | | 2448 | | 28 |
| | | 25734 | | 259 | |
| 5·6 | 270·426 | | 2707 | | |
| | | 28441 | | | |
| 5·7 | 298·867 | | | | |

Writing $y = 5{\cdot}2 + {\cdot}1x$, and $u_x = 10^3 e^y$, so as to get rid of decimals, we have the following values corresponding to $y = 5{\cdot}2$ $(x = 0)$:—

| $u_0$ | $a_0$ | $b_0$ | $c_0$ | $d_0$ | $e_0$ |
|---|---|---|---|---|---|
| 181272 | 18157½ | 1815 | 181½ | 15 | 2½ |

With this notation, the value of $u_x$ for values of $x$ between $-\frac{1}{2}$ and $+\frac{1}{2}$ is given by

$$u_x = u_0 + xa_0 + \frac{x^2}{2!}b_0 + \frac{x(x^2-1)}{3!}c_0 + \frac{x^2(x^2-1)}{4!}d_0 + \frac{x(x^2-1)(x^2-4)}{5!}e_0 + \ldots\ldots \quad \text{(i.)}$$

This is a well-known formula. Differentiating with regard to $x$, and putting $x = 0$, we have (writing $u$ for $u_x$)

$$\left(\frac{du}{dx}\right)_0 = a_0 - \tfrac{1}{6}c_0 + \tfrac{1}{30}e_0 - \tfrac{1}{140}g_0 + \ldots\ldots \quad \text{(ii.)}$$

Similarly, differentiating twice, and putting $x = 0$,

$$\left(\frac{d^2u}{dx^2}\right)_0 = b_0 - \tfrac{1}{12}d_0 + \tfrac{1}{90}f_0 - \tfrac{1}{560}h_0 + \ldots\ldots \quad \text{(iii.)}$$

Prof. Everett's formula for the "increase-rate" when fifth differences are negligible is obtained by taking the first two terms of (ii.).

(2) The advantage of these formulæ, as Prof. Everett points out, is their greater accuracy. The ordinary formula

$$\Delta - \tfrac{1}{2}\Delta^2 + \tfrac{1}{3}\Delta^3 - \tfrac{1}{4}\Delta^4 + \tfrac{1}{5}\Delta^5,$$

in the above example, would give for $y = 5{\cdot}2$

$$\frac{du}{dx} = 18131\tfrac{1}{2},$$

while, if the differences were taken backwards, we should get

$$\frac{du}{dx} = 18124\tfrac{1}{5}.$$

The formula (ii.), taken to the fifth central difference, gives

$$\frac{du}{dx} = 18127\tfrac{1}{3},$$

the true value being

$$\frac{du}{dx} = 18127{\cdot}224.$$

The inaccuracy in the ordinary formula is, of course, due to the fact that a table such as the above never gives the exact value of the function tabulated, but only the nearest integral multiple of a certain unit (in this case ·001). If we denote this unit by $\rho$, each tabulated value differs from the true value by some quantity lying between $-\frac{1}{2}\rho$ and $+\frac{1}{2}\rho$. It may be shown that this makes it possible for $\Delta - \frac{1}{2}\Delta^2 + \frac{1}{3}\Delta^3 - \frac{1}{4}\Delta^4$ to differ from its true value by as much as $\frac{16}{3}\rho$, while $a_0 - \frac{1}{6}c_0$ cannot differ from its true value by more than $\frac{3}{4}\rho$. Hence this latter formula is more accurate than the ordinary one in the ratio of 64 : 9, or about 7 : 1, when fifth differences are negligible. When only seventh differences are negligible, the formula $a_0 - \frac{1}{6}c_0 + \frac{1}{30}e_0$ is more accurate than the ordinary formula, in the ratio of 832 : 55, or about 15 : 1.

(3) The formulæ (ii.) and (iii.) give the first and second differential coefficients for the values of the "argument" shown in the table. It is often more useful to have them for the *intermediate* values. This requires a modification of the method of central differences. Let us write

$$\begin{aligned}
\tfrac{1}{2}(u_1 + u_0) &= \mathrm{V} \\
\Delta u_0 &= \Delta_1 \\
\tfrac{1}{2}(\Delta^2 u_0 + \Delta^2 u_{-1}) &= \Delta_2 \\
\Delta^3 u_{-1} &= \Delta_3 \\
&\text{\&c.}
\end{aligned}$$

Thus for the interval from 5·2 to 5·3, in the above example, we have

| V | $\Delta_1$ | $\Delta_2$ | $\Delta_3$ | $\Delta_4$ | $\Delta_5$ |
|---|---|---|---|---|---|
| $190804\frac{1}{2}$ | 19065 | $1909\frac{1}{2}$ | 189 | $19\frac{1}{2}$ | 9 |

With this notation, it may be shown that, for any value of $x$ from 0 to 1,

$$\begin{aligned}
u_x = &\left\{\mathrm{V} - \frac{1-2x}{2}\Delta_1\right\} \\
&- \frac{x(1-x)}{2\,!}\left\{\Delta_2 - \frac{1-2x}{6}\Delta_3\right\} \\
&+ \frac{x(1-x^2)(2-x)}{4\,!}\left\{\Delta_4 - \frac{1-2x}{10}\Delta_5\right\} \\
&- \frac{x(1-x^2)(4-x^2)(3-x)}{5\,!}\left\{\Delta_6 - \frac{1-2x}{14}\Delta_7\right\} \\
&+ \ldots\ldots\ldots\ldots\ldots\ldots \quad \text{(iv.)}
\end{aligned}$$

Or, if we write $x = \frac{1}{2} + \theta$, then for values of $\theta$ from $-\frac{1}{2}$ to $+\frac{1}{2}$,

$$\begin{aligned}
u_{\frac{1}{2}+\theta} = &\{\mathrm{V} + \theta\Delta_1\} \\
&- \frac{1-4\theta^2}{2^2.2\,!}\left\{\Delta_2 + \tfrac{1}{3}\theta\Delta_3\right\} \\
&+ \frac{(1-4\theta^2)(9-4\theta^2)}{2^4 \cdot 4\,!}\left\{\Delta_4 + \tfrac{1}{5}\theta\Delta_5\right\} \\
&- \ldots\ldots\ldots\ldots\ldots\ldots \quad \text{(v.)}
\end{aligned}$$

Differentiating this last expression twice with regard to $\theta$, and putting $\theta = 0$ we find

$$\left(\frac{du}{dx}\right)_{\frac{1}{2}} = \Delta_1 - \frac{1}{24}\Delta_3 + \frac{3}{640}\Delta_5 - \frac{5}{7168}\Delta_7 + \ldots\ldots \quad \text{(vi.)}$$

$$\left(\frac{d^2u}{dx^2}\right)_{\frac{1}{2}} = \Delta_2 - \frac{5}{24}\Delta_4 + \frac{259}{5760}\Delta_6 - \frac{3229}{322560}\Delta_8 + \ldots\ldots \quad \text{(vii.)}$$

Thus for $y = 5{\cdot}25$, in the above example, we find

$$\frac{du}{dx} = 19057{\cdot}17,$$

the true value being

$$\frac{du}{dx} = 19056{\cdot}63.$$

(4) The ormula (iv.) is useıul for constructing tables by means of interpolation. For halving the intervals in a table, it gives

$$u_{\frac{1}{2}} = \mathrm{V} - \tfrac{1}{8}\Delta_2 + \frac{3}{128}\Delta_4 - \frac{5}{1024}\Delta_6 + \frac{35}{32768}\Delta_8 - \ldots \quad \text{(viii.)}$$

Similarly, for subdivision of the intervals into fifths,

$$\begin{aligned}
u_{\frac{1}{5}} = \mathrm{V} &- {\cdot}3\Delta_1 - {\cdot}08\Delta_2 + {\cdot}008\Delta_3 + {\cdot}0144\Delta_4 - {\cdot}000864\Delta_5 \\
&- {\cdot}0029568\Delta_6 + {\cdot}00012672\Delta_7 + {\cdot}00064204 8\Delta_8 - \ldots \\
u_{\frac{2}{5}} = \mathrm{V} &- {\cdot}1\Delta_1 - {\cdot}12\Delta_2 + {\cdot}004\Delta_3 + {\cdot}0224\Delta_4 - {\cdot}000448\Delta_5 \\
&- {\cdot}0046592\Delta_6 + {\cdot}00006656\Delta_7 + {\cdot}001018368\Delta_8 - \ldots \quad \text{(ix.)} \\
u_{\frac{3}{5}} = \mathrm{V} &+ {\cdot}1\Delta_1 - {\cdot}12\Delta_2 - {\cdot}004\Delta_3 + \text{\&c.} \\
u_{\frac{4}{5}} = \mathrm{V} &+ {\cdot}3\Delta_1 - {\cdot}08\Delta_2 - {\cdot}008\Delta_3 + \text{\&c.};
\end{aligned}$$

the terms in $u_{\frac{3}{5}}$ and $u_{\frac{4}{5}}$ being the same as in $u_{\frac{2}{5}}$ and $u_{\frac{1}{5}}$, but with signs alternately alike and different; and the sequence of signs in each case being . . . + + − − + + . . . The corresponding formulæ for subdivision into tenths might be found; but it is simpler to subdivide into halves and then again into fifths.

When several differences have to be taken into account, the above method of direct calculation is less troublesome than the ordinary process of building up the table by calculation of the sub-differences.

In the formulæ (ix.) the terms due to V and $\Delta_1$ have been given in the form $\mathrm{V} - {\cdot}3\Delta_1$, $\mathrm{V} - {\cdot}1\Delta_1$, . . . ; but in practice these terms would be obtained by successive additions of $\cdot 2\Delta$ to $u_0$, so that it is not necessary to calculate V.

August 16. W. F. SHEPPARD.

## Apparent Dark Lightning Flashes.

ON the evening of the 5th of the present month we were visited by a severe thunderstorm, which passed practically over this place. The lightning was very vivid and at times occurred at intervals of only a few seconds. In order to photograph some of the flashes I placed a camera on my window sill and exposed four films for consecutive periods of 15 minutes each.

During the exposures I was observing the sky, and repeatedly found that after nearly each bright flash I could see distinctly a *reversed image* of each flash *in any part of the sky* to which I turned my head. These apparent dark flashes, or rather the images on my retina, lasted for sometimes 5 to 10 seconds. At the time I wondered whether dark flashes had ever been noticed before, and thought that this phenomenon was not uncommonly observed, but seeing Lord Kelvin's letter in your issue of August 10, I send this note in case it may prove of interest.

Westgate-on-Sea, August 13. WILLIAM J. S. LOCKYER.

## Subjective Impressions due to Retinal Fatigue.

IN reading the interesting optical experience as described by Lord Kelvin in NATURE of August 10, it occurred to me that a somewhat similar effect on the eye, as noticed by myself, might be of interest.

Frequently late in the evening, and with a dull cloudy sky, I have seen my own figure, at least in part, apparently projected in gigantic form high up on the cloudy background.

This happened in the following manner. Going to the door of the house, and standing there with the strong light from the lobby or hall lamp shining out upon the gravel-walk in front, I saw my figure in shadow strongly defined upon the illuminated pathway. On raising my eyes quickly to the sky, I there saw the same form marked out on the dark clouds, but in a lighter shade.

The effect on the eye, as in Lord Kelvin's experience, is doubtless that of fatigue: in my experience, however, the form observed being very dark as compared with the illuminated background, I received the complementary impression of a light-coloured figure on a dark background.

The time during which this impression remained when looking at the clouds might be a couple of seconds.

August 14. W. J. MILLAR.

## Mathematics of the Spinning-Top.

IT should have been stated on p. 321 that, while $\theta_3$ is the angle between HQ and HQ′ in Fig. 1, p. 347, the angle between HS and HS′ is $\theta_2$. At the same time this opportunity is available for some corrections, for which the printers are not responsible. On p. 321 the values of sin $\theta_3$ and sh $\theta_1$ should be interchanged; on p. 348, after equation (35), read ... "MX is the harmonic mean of MT, MT′ and of M*m*, M*m*′, ..."

August 12. A. G. GREENHILL.

## ON SPECTRUM SERIES.[1]

### II.

It is well that I should indicate the basis of these statements, and for this purpose I throw on the screen a very small part of the spectra of two or three different substances in order that you may see the way in which the work has been done. Take the lowest horizon. There we are dealing with zinc, and you see the way in which the triplets have been picked out. The triplet in each case, of course, supposing it is the remnant of a fluting, has its central line nearer to one side of the triplet than the other. All the triplets in the zinc spectrum are perfectly symmetrical from that point of view. If we take the upper spectrum—that of calcium—we find also that the triplets are formed in exactly the same way. We can quite understand the enormous labour which has been involved on the part of the inquirers I have named in working out from the spectra of a great many substances and from all the different regions of the spectrum, visible and photographic, these delicate triplets. In a great many cases they do not represent the strongest lines, those most easily seen, and they want a great deal of looking for.

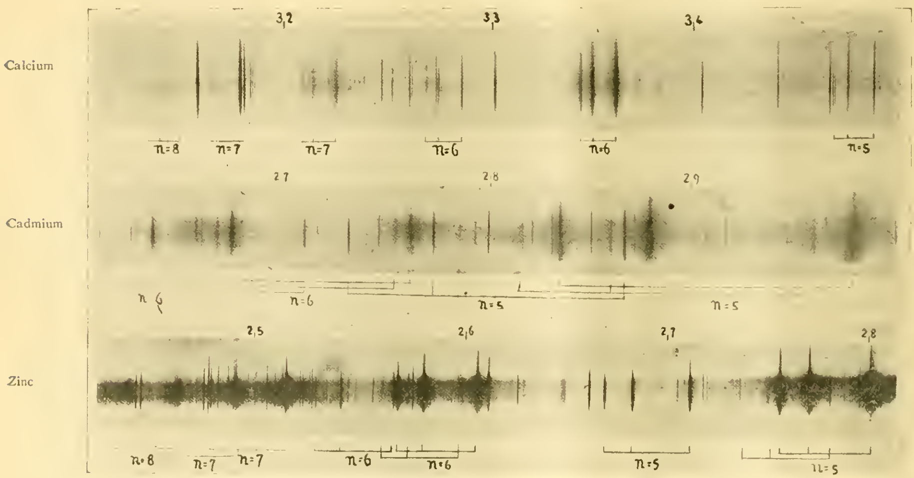


FIG. 6.—Parts of the spectra of calcium, cadmium and zinc showing the triplets.

I next pass on to some more general statements, which I am anxious to put before you for the reason that you will not find them stated in any literature that I am acquainted with; the subject has really not been generally discussed at all.

Some substances have three series, as in the case of helium and asterium. There are others like them; and the most remarkable case which I have to bring before you is that of hydrogen. We do not know the meaning of it yet, but it has to be taken into account in any consideration of these questions. Until a little time ago only one series was known in the spectrum of this gas, and it was thought that on that account the atom of hydrogen was far more simple than that of any other chemical elements. A short time ago, however, Prof. Pickering, in his magnificent work on the stars, to which I have already had the opportunity of referring, discovered a second series of lines. Not long after, Prof. Rydberg suggested that one of the most important lines seen in a large group of stars really represented a line of the principal series of hydrogen. That conclusion has been generally accepted, although the evidence is considered doubtful by some; so that we now assume that hydrogen has three series like helium and asterium, and we seem therefore to be on solid ground in one direction, at all events, in regard to some gases. We have another series of metals of low atomic weight, and which therefore chemically are supposed to represent a considerable simplicity; we find that in the case of lithium and sodium we also deal with three series, a principal series and two subordinate series. The series of lithium are just as beautiful in their rhythm as the other series to which I have referred. The same remark applies exactly to sodium. Now, it has recently been found that sulphur and selenium also give us three series. We have a principal series and the first and second subordinates, but the suggestion of anything beyond these three is confined to one or two lines in each case. Next let us take another gas, and see what happens in the case of oxygen. *We have six series*, that is twice as many as we know of in hydrogen, helium, asterium, lithium, sodium, sulphur, and so on. I should say that so far as that goes we are in the same condition that we were some time ago when we imagined that the gas obtained from the mineral cleveite was really a single gas with six series. Very many arguments have been employed to show that that view is probably not an accurate one; so that some are prepared to separate the cleveite gases at spark temperatures into two, calling one helium and the other asterium. That brings these two constituents of the cleveite gas then to the same platform as hydrogen with the recent developments, lithium, sodium, sulphur, &c. If we come to consider this extraordinary condition in the case of

[1] A Lecture to Working Men, delivered at the Museum of Practical Geology, on May 1, by Prof. Sir Norman Lockyer, K.C.B., F.R.S. (Continued from p. 370.)

oxygen a little further, we find that the six series only after all pick up the oxygen lines seen at a low temperature, and that if we employ a high temperature to observe the oxygen spectrum, that is to say, if we use an induction coil, a jar and an air break, we find a very considerable number of lines indeed which have no connection whatever with the series. And we are face to face with this very awkward fact, that in the case of oxygen there are more lines which we cannot get into a series than there are lines in the six series which we have attributed to that chemical substance. Here, therefore, we begin certainly to get into difficulties. The inquiry is not so straightforward, the conditions are not so constant, as we might have expected them to be.

Here then we have instead of three series twice that number, and these only account for about half the lines. Now, let us look still a little further. The next point is that in the case of other substances *we have no principal series*, but only two subordinate ones. This happens in the case of magnesium, calcium and strontium. We have only two series in the case of magnesium, two in calcium, and two in strontium. In all those three we have a first and second subordinate series, but no principal series. I have studied the lines of calcium and magnesium, in the same way that the lines of oxygen were studied to see how many of the lines are picked up by the series. In the upper part of the diagram we have the lines seen in the arc spectrum of calcium, and in the two next horizons we have the lines picked up in the first and second subordinate series. The next horizon gives the residual lines—lines, that is, which have not been distributed into any of these series. You see that there is a large number outstanding just as in the case of oxygen, and it is very important indeed to note that the two lines H and K, which are more conspicuous in the spectrum of the sun than all the other lines of the spectrum, have not been caught by any of these researchers into the series of calcium. Therefore, with a reduced number of series, we seem to be getting still further from the simplicity we began with in the case of some of the permanent gases like hydrogen and helium. The same thing holds with regard to magnesium, the spectrum of which at the temperature of the arc has not so many lines in it as the spectrum of calcium. A certain number of these lines has been picked up to form the series, but we get numerous lines which have been left over after all attempts to sort them into series have been made.

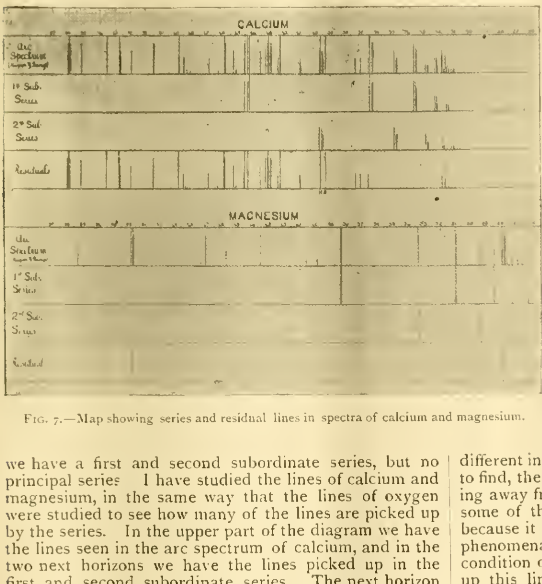


FIG. 7.—Map showing series and residual lines in spectra of calcium and magnesium.

I have now to bring before you another consideration. We are dealing in the case of calcium and magnesium with arc temperatures, but I showed you in my first lecture that in the case of calcium and magnesium the all-important lines in the hottest stars were lines seen at the temperature of the spark. I have added these lines to the diagram, and you will see that there is not the slightest trace of those lines having been picked up in the series. So that the further we go, the more we seem to get away from that beautiful simplicity with which we began. I take you now to another group of substances, namely, tin, lead, arsenic, antimony, bismuth and gold, and I might mention more. No series whatever have as yet rewarded the many attempts of those who have tried to get those metals and non-metals on all-fours with those previously investigated. It remained for Kayser and Runge to point out that it looked very much as if this complete absence of series was connected with the melting point of the substances with which they had been dealing. So long as the melting point was low, as in the case of sodium and lithium, the normal three series would show at low temperatures; and, further, there were no lines over. But, when you get to these substances with high melting points, there is no series at all, and of course it is suggested that therefore there must be intermediate stages; and that really seems to be a very valid suggestion indeed, and one which in all probability will enable us to get over some of the difficulties. They point out that in the case of lithium, sodium, potassium, &c., all the lines are picked up, and that in the case of copper, silver and gold the series pick up only a very small proportion. There seems, therefore, to be a progression of complexity with the increasing melting point with regard to all the metallic substances which have so far been examined; of course this consideration does not touch the question of oxygen. Oxygen is a gas, hydrogen is a gas in consequence, of course, of their very low melting points, and you know that quite recently it has been found possible to liquefy both of them. So that there must be something different in their case, and it seems extremely encouraging to find, therefore, that the same variation, the same breaking away from the law which I pointed out in the case of some of the metals, should really occur also in a gas, because it seems as if we shall be able to explain the phenomena in both cases by supposing that there is a condition of greater complexity, and that when we follow up this line of greater and greater complexity, whether in a gas such as oxygen, or in a solid such as gold, we do not get the simple series, because at the temperatures we employ we are still far from the simple condition which we can get at in some gases and in some metals with low melting points. The table gives the relation between the melting point and the percentage of lines sorted into series. Thus, in the case of barium with a high melting point we get no lines at all represented in the series; then we gradually get up to 100 per cent. in the case of lithium. But then again, as in the case of oxygen, when we come to mercury, which is also of low melting point, instead of getting 100 per cent. we only get about 25 per cent. of the lines represented in the series.

Relation of series to melting points.

| Element | Melting point | Percentage of series lines |
|---|---|---|
| Barium ... ... | 1600° | 0 |
| Gold ... ... | 1200 | 4 |
| Copper ... ... | 1050 | 6 |
| Silver ... ... | 960 | 26 |
| Strontium ... | 700 | 20 |
| Calcium... ... | 700 | 34 |
| Magnesium ... | 600 | 64 |
| Zinc ... ... | 410 | 80 |
| Cadmium ... | 320 | 50 |
| Lithium... ... | 180 | 100 |
| Sodium ... ... | 90 | 100 |
| Cæsium... ... | 62 | 100 |
| Potassium ... | 58 | 100 |
| Rubidium ... | 38 | 100 |
| Mercury... ... | – 40 | 27 |

These matters, of course, have been very carefully inquired into, and among them I will just point out that Meyer has shown that if the wave-lengths of all the lines for $n = \infty$ be calculated and put as ordinates, and the atomic weights as abscissæ, then all the points lie on a curve similar to that which gives the atomic volumes as functions of the atomic weights. He not only deals with the melting points, but he goes further and attempts to associate the melting points with the atomic weights.

The next consideration is that in these investigations, in some cases, the series have reproduced the same chemical group, but in some instances the series groupings, so to speak, are quite different from the chemical groupings.

The facts so far ascertained are as follows:—

Group 1 ... Lithium, Sodium, Potassium, Rubidium, Cæsium.
,, 2 ... Copper, Silver, (Gold ?).
,, 3 ... Magnesium, Calcium, Strontium.
,, 4 ... Zinc, Cadmium, Mercury.
,, 5 ... Aluminium, Indium, Thallium.

In the group of lithium, sodium, potassium, the series sequence follows absolutely the chemical sequence. But when we come to the chemical group—calcium, strontium, barium—you find it replaced by a group, magnesium, calcium, strontium, while barium is not used at all. That is a very remarkable departure, and it shows that we have to consider the various conditions which we observe in passing from group to group.

From *group* to *group* with increasing atomic weights the series back towards the violet. Thus, as the limit of a series is represented by the first constant for the first subordinate of the four groups, the limit lies

Between 2858·6 and 1974·3 for Lithium, Sodium, Potassium, Rubidium, Cæsium.
,, 3159·1 ,, 3078·2 ,, Copper, Silver, Gold.
,, 3979·6 ,, 3103·0 ,, Magnesium, Calcium, Strontium.
,, 4294·5 ,, 4015·9 ,, Zinc, Cadmium, Mercury.

In *each group* with the increasing atomic weight the spectrum advances continually towards the red end; that is, in exactly the opposite direction we observed before.

Having dealt with these details, there are several other general questions which I should like to say a word about, because it is evident that we are here in presence of the beginning of a new attack on the nature of the chemical elements.

Let us attempt to compare these simplest results obtained by this newest form of spectrum analysis, in other words the simplest series, with the earliest stellar forms.

We found that the hottest stars contained hydrogen, helium, and asterium. Well, we have found that those substances have the simplest series; that is to say, one set of three. I told you that it was more than probable, although it is not absolutely established, that the lithium group of metals is also represented in stars of very high temperature. There, again, we have the simple series of one set of three. About sulphur we do not yet know positively, but it is probable, I think, that sulphur may exist in the hot stars. There, again, we get another simple set of three; so that for three perfectly certain members of the hottest stars, together with one in all probability and one doubtful, we are dealing with the simplest series in the hottest stars.

But now comes the remarkable fact that side by side with these simple substances we get in the hottest stars magnesium and calcium. We cannot suppose that the absence of the principal series there means a greater simplicity, because I have shown you that only about half the lines in the spectrum of each of these substances has yet been picked up in the series, and if the series represent the vibrations of a single particle, of course the lines which are not represented in the series, by theory must represent the vibrations of some other particles. So that there we are face to face with the possibility of a much greater complexity. Coming a little further down in stellar temperatures we find oxygen, and here we deal with six series instead of three, or two, as in the case of magnesium and calcium; and even then, as I have pointed out to you, we do not deal with above half the lines of the gas as we can see them at a higher temperature. This, then, seems to suggest that in the hottest stars there are very various stabilities of very various forms. In fact, there seems to be there as here distinctly the survival of the fittest; otherwise how can we account for the fact that certainly in the hottest stars we get two metals, magnesium and calcium, before we have indication of any other metals, and that where we have those metals and bring our series touch-stone to them we find that instead of being very simple they are really very complex? However this may be, we are now assured that there is a much greater quantity of some apparently more complex forms in the hotter stars than of the more simple ones; and that is a matter which the chemists, when they come to inquire into these questions which we are now considering, will certainly have to face. This fact suggests, too, another very interesting question which has some relation, perhaps, to some of those drawings that I have thrown on the screen from Lyell's Elements, which showed that a great many simple organic forms appear in the stratigraphic series at a late period; that some of the simplest forms died out, others remained. Now, it may be that some of the more simple forms in inorganic evolution, as in organic evolution, really represent later introductions; but, however this may be, it is perfectly certain that we have not an absolute parallel between the results of the spectroscopic observations of series and the spectroscopic observations of stars. The accompanying table will show very generally how the matter stands. The chief points to refer to are the gaps in the table showing the principal series and the first and second subordinate series. We have the metals arranged in the order of Mendeléjeff's groups. You will observe that after the first metals we practically deal with no principal series at all until we come down at the bottom to oxygen, sulphur and selenium. The same thing happens with the subordinate series so far as the existence of single lines and double lines are concerned. Now, it is a curious point that in the case of several of those substances in which no principal series has been detected, certain lines in the ultra-violet of considerable strength have been observed which may ultimately turn out to represent principal series. Of course, if that should be so it will make the inquiry a

very much simpler one than it appears to be at present, and it may possibly break down that terrible amount of uncertainty and irregularity which it has been my duty to point out to you in the series so far examined.

there is no fluting from one end of the spectrum to the other..

Rydberg has suggested that an investigation of the so-called "longest-lines" of the various substances may

| | Mendff. groups. | Atomic weights. | No. of series. | No. of principal series. | Principal series. Single. | Principal series. Double. | Principal series. Triplets. | 1st and 2nd subordinate. Single. | 1st and 2nd subordinate. Double. | 1st and 2nd subordinate. Triplet. | REMARKS. | Per cent. of total number of lines picked up by K. and R. | Per cent. of lines of intensity 10, picked up in series. | Melting points, degrees C. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HYDROGEN | — | 1 | 3 | 1 | — | Double ? | — | — | Double | — | — | 100 | 100 | — |
| HELIUM ... | — | — | 3 | 1 | Single | — | — | — | Double | — | In sub. series the double represents strong member with faint companion. Helium really gives a spectrum of six series, but one set of three series has been called Asterium. | 100 | 100 | — |
| ASTERIUM | — | — | 3 | 1 | Single | — | — | Single | — | — | | 100 | 100 | — |
| LITHIUM | | 7·0 | 3 | 1 | — | Double ? | — | — | Double ? | — | — | 100 | 100 | 180 |
| SODIUM ... | | 23·0 | 3 | 1 | — | Double | — | — | Double | — | The pairs in all cases widen as the atomic weights increase. | 100 | 100 | 90 |
| POTASSIUM | I. | 39·0 | 3 | 1 | — | Double | — | — | Double | — | | 100 | 100 | 58 |
| RUBIDIUM | | 85·2 | 1 | 1 | — | Double | — | Not observed | | | | 100 | 100 | 38 |
| CÆSIUM ... | | 13·3 | 1 | 1 | — | Double | — | Not observed | | | | 100 | 100 | 62 |
| COPPER ... | | 63·4 | 2 | 0 | — | — | — | — | Double | — | Each element contains in the ultra-violet a very strong pair of lines which may be principal series. | 6 | — | 1080·5 |
| SILVER ... | I. | 107·6 | 2 | 0 | — | — | — | — | Double | — | | 26 | — | 960 |
| GOLD ... | | 196·7 | 0 | 0 | — | — | — | — | — | — | | ? | — | 1061·7 |
| MAGNESIUM | | 24·3 | 2 | 0 | — | — | — | — | — | Triplets | 2852·2 and some pairs not picked up by these series. | 64 | 55 | 600 |
| CALCIUM | II. | 39·9 | 2 | 0 | — | — | — | — | — | Triplets | Some more triplets and pairs not picked up by these series. | 34 | 17 | 700 |
| STRONTIUM | | 87·4 | 2 | 0 | — | — | — | — | — | Triplets | — | 20 | 7 | 700 |
| BARIUM ... | | 136·8 | 0 | 0 | — | — | — | — | — | — | — | — | — | 475 |
| ZINC ... | | 65·1 | 2 | 0 | — | — | — | — | — | Triplets | In each case a very strong broad reversed line in the ultra-violet may be principal series. | 80 | 43 | 410 |
| CADMIUM | II. | 111·7 | 2 | 0 | — | — | — | — | — | Triplets | | 50 | 14 | 320 |
| MERCURY | | 199·8 | 2 | 0 | — | — | — | — | — | Triplets | | 27 | 12·5 | −40 |
| ALUMINIUM | | 27·0 | 2 | 0 | — | — | — | — | Double | — | — | — | 25 | 654·5 |
| INDIUM ... | III. | 113·7 | 2 | 0 | — | — | — | — | Double | — | — | — | 25 | 176 |
| THALLIUM | | 203·7 | 2 | 0 | — | — | — | — | Double | — | — | — | 17 | 282 |
| TIN ... ... | IV. | 117·8 | 0 | 0 | — | — | — | — | — | — | No series have been discovered, but there seem to be groupings of lines which recur very frequently. The lines do not form series. | — | — | 232 |
| LEAD ... | | 206·4 | 0 | 0 | — | — | — | — | — | — | | — | — | 326 |
| ARSENIC | | 74·9 | 0 | 0 | — | — | — | — | — | — | | — | — | 450 |
| ANTIMONY | V. | 119·6 | 0 | 0 | — | — | — | — | — | — | | — | — | 629·5 |
| BISMUTH | | 207·5 | 0 | 0 | — | — | — | — | — | — | | — | — | 270 |
| OXYGEN ... | | 15·88 | 6 | (2) | — | — | Triplets | — | — | Triplets | — | — | — | — |
| SULPHUR | VI. | 31·8 | 3 | 1 | — | — | Triplets | — | — | Triplets | These probably have six series. One strong triplet is observed which may be principal series of second set of three series. | — | — | 114 |
| SELENIUM | | 78·5 | 3 | 1 | — | — | Triplets | — | — | Triplets | | — | — | 217 |

Another matter of considerable importance to us in attempting to arrange the chemical elements along this line of series—and it is work that is sure to be done now that the matter is started—is to endeavour to see if there is any strict relation between those chemical substances which give us these simple series and those which are more apt to provide us with those exquisite rhythmic flutings. In some of the elements the flutings and the proportions of them from one end of the spectrum to the other are very remarkable, but in other metals the wonderful thing about them is that practically

eventually help us in our inquiries. I will tell you what the longest-line means. If we examine a light source by pointing the spectroscope directly at it, of course the rays from every part of the light source enter the instrument; but if we throw an image of the light source on the slit of the spectroscope, then those particles which exist furthest from the centre will be visible furthest from the image of the centre, and therefore if they are visible enough to give spectra, we should get long lines stretching from the centre to the very limit at which their light is visible enough to be utilised by the instrument. As a

matter of fact we do see some very long lines in this way in the case of some substances, and these of course appear to be quite distinct from the shorter lines which are limited to the exact centre of the spark or the arc; to the region, that is, in which the very highest temperature is at work. Rydberg has shown that in a considerable number of cases long lines seem to have a very considerable importance, and on that account it is well worth inquiring into. Rydberg's investigations of the members of the first three groups of the periodic system led him to conclude that the long lines form pairs or triplets, which in the case of each element are characterised by a constant difference ($v$) in the number of waves of the components. For each group of elements shown in Mendeléjeff's table, this value he finds increases in a ratio somewhat exceeding the *square* of the atomic weight.

What, then, is the general result ot our inquiry, taking series in inorganic evolution to represent the cells which are microscopically studied in the case of organic evolution? I think you will agree that the evidence is that, however simple the organic cell may be, the chemical units in the case of any substance represented to us by the movements which are written out by these series must possess different degrees of complexity. I have already told you that a little time ago it was imagined that hydrogen was rendered visible to us by such simple vibrations that only one series of lines could be produced. If that is so, then it looks very much as if whenever we see three series of lines that three molecules or atoms, three different things, are in all probability at work in producing them. When we get six series, that points to a still greater complexity, and when as in the case of oxygen we get six series not accounting for half the lines, then we should be quite justified, I think, in supposing that oxygen was one of the most complex things that we were brought face to face with in our studies of series. When we come to metals where there are no series at all, what do we find? We find that we are dealing with substances with high melting points—that is to say, we cannot bring them down easily to those mobile states represented by the free paths of a permanent gas; and it is quite easy to suppose, on that account alone, that we do not see the vibrations of any of the more simple forms. Therefore, I think it is perfectly certain that we have not universally got down to the equivalent of the cell-level in our study of chemical forms.

With regard to this question of the relation of the two evolutions inorganic and organic, I have still one more diagram which will give an idea of the place of organic evolution in regard to inorganic evolution in the scale of time. I do not want you to pay too much attention to this diagram, because it is entirely hypothetical; but it is constructed on the simplest principles, so that it shall go as little wrong as may be. I begin by drawing a line at the bottom, which represents the zero of temperature; certain temperature values are indicated on the left-hand side of the diagram. Then we have the assumption that a star loses an equal amount of heat in an equal period of time. In that way, then, you see at the bottom we have relative times, as at the side we have temperatures, in Centigrade degrees. Water freezes at a certain temperature above absolute zero, and boils at a certain other point; these are marked on our temperature scale. Then we have to remember that about half-way between the boiling point and the freezing point, all the organic life with which we are familiar on this planet, from the geological evidence and our own experience, must have gone on at a temperature of somewhere about, let us say, from 50° to 40° Centigrade. There, then, we get the limit of organic life in relation to the possible inorganic life, represented by the various chemical changes in the stars. We know from laboratory statements that the stars of lowest temperature are about the same temperature as that of the electric arc, which is about 3500° C., and so we put the Piscian stars there. It has also been stated by Mr. Wilson lately that the temperature of the sun measured by several physical methods is something between 8000° and 9000° C., so that we put there the Arcturian stars. Of course we have no means of determining the temperatures of the hotter stars, so I have ventured to make a very modest supposition that possibly we get about half the difference of temperature between those stars as we have found between the Piscian and the Arcturian stars from experiments on the earth. That will give us roughly something like 5000° C. We find then that if we assume equal increments of temperature for each of the different genera of stars that I brought before you in the second lecture, we get a temperature at the top of the diagram of something like 28,000° Centigrade. All we have to do, then, is to draw a diagonal line on which to mark the various temperatures considered. On this the organic evolution, which represents everything which has taken place with regard to living forms on the surface of our planet from the pre-Laurentian times to our own, is represented by a small dot. It looks, therefore, very much as if these recent results of spectrum analysis, which it has been my duty and my pleasure to bring before you in this course of lectures, may probably be of some value in the future, because they deal with a multitude of changes and a period of time compared with which all the changes discussed by the geologists are almost invisible on a diagram of this size. Not only shall we have probably some help in determining this scale, but I think that, as I have already indicated to you, the wonderful similarity between the substances contained in the organic cell and those which would most likely be free when the greatest amount of chemical combination had taken place on the surface of the cooling world, will throw some light on the basis of organic evolution itself.

In that way, then, we have really been only continuing courses of lectures given here formerly, which had to do with Man's Place in Nature, and with the Sun's Place in Nature; and I think you will agree that we have found fresh grounds for thinking that the more different branches of science are studied and allowed to react on each other, the more the oneness of Nature impresses itself upon the mind.

## *NOTE ON THE DISCOVERY OF* MIOLANIA *AND OF* GLOSSOTHERIUM (NEOMYLODON) *IN PATAGONIA.*[1]

SINCE 1877, when I discovered the Tertiary Mammalian beds of Santa Cruz, in Patagonia, I have been looking for proofs of the ancient connection between the new uplifted lands of the southern part of the American continent and the other lands of the Southern Hemisphere—Africa and Australia. During my subsequent travels in the interior of the Argentine Republic, including Patagonia, my interest in that connection has been increasing, and I have discovered additional evidence, which showed me the former greater extension to the east, in comparatively modern times, of the actual existing lands. The splendid results of the researches made by the La Plata Museum in Patagonia have revealed a greater number of lower forms of vertebrates, including numerous marsupialia, some of which seem to me closely related to the mammals of the Pleistocene fauna of Australia, and among them *Pyrotherium* and *Diprotodon*. I think that my suggestion has an indubit-

[1] By Dr. Francesco P. Moreno, Director of the La Plata Museum. (This article will appear in the *Geological Magazine* for September 1, and is printed in advance in NATURE, by permission of Dr. H. Woodward, F.R.S.)

able confirmation in the discovery made by the expeditions which I sent in 1897 and in the first months of this year, under the direction of Mr. Santiago Roth, expeditions that have had astonishing results.

In beds containing remains of mammals and dinosaurians, Mr. Roth discovered in 1897 a caudal sheath-ring, very similar to those of the *Glyptodon*, but which I at once recognised as pertaining to a form like the chelonian of the Pleistocene of Queensland, described by Owen. I brought this fossil with me to London for comparison with the remains of *Miolania* preserved in the British Museum (Natural History). The resemblance was great, but the fact of a Tertiary chelonian from

B. A.

FIG. 1.—A, front view of skull; and B, side view of tail-sheath, of *Miolania Oweni* (greatly reduced in size) from Pleistocene deposits, Queensland, Australia [originally described as *Megalania prisca* by Owen in 1880].

Patagonia being analogous to the Pleistocene genus from Queensland and Lord Howe Island was so astonishing that some doubt was permitted; but, having previously ordered a new examination of the fossiliferous bed where the remains were found, I have now the certainty of the extremely close relation between the Australian and Patagonian chelonian. I have received several photographs of a skull discovered by Mr. Roth, which photographs, when compared with the Australian specimens in the British Museum (Natural History), give no place for doubt upon this matter. I think that it is sufficient for the present to give two cuts representing the two forms of *Miolania*. I expect in a few days the original specimen from Patagonia, together with various bones and additional remains of the caudal sheath, with some of the carapace. These will be the subject of a special description by Mr. Arthur Smith Woodward, who has so kindly commenced studies on the fossil reptiles in the La Plata Museum.

I have also brought with me to London a piece of a skin discovered in a cave near Last Hope Inlet (lat. S. 51° 30′), which I have referred to a species of the extinct *Mylodon* (see "On a Portion of Mammalian Skin, named *Neomylodon listai*, from a Cavern near Consuelo Cove, Last Hope Inlet, Patagonia," by Dr. F. P. Moreno; with a description of the specimen by A. Smith Woodward); while Mr. Ameghino has announced that another piece of the same skin pertains to a mammal still living, of small size, which he has called *Neomylodon*. When I took this piece at Last Hope Inlet in November 1898, I was convinced that it was part of the skin of a *Mylodon* or a form very similar to it, and that the discovery was of great importance to me, as I think that the Pampean muds, where the extinct Edentata are found, are of very modern age; an opinion contrary to that held by another observer, Mr. Ameghino, who refers the Pampean fauna to the Tertiary age. I have already maintained that the extinction of the greater part of the Pampean fauna took place after the presence of man in a relatively advanced culture, called Neolithic culture. Having, then, great interest in the continuation of the investigations in the cave, I ordered, before coming to London, more extensive researches, and these have been made with very successful results.

Dr. Otto Nordenskjöld had previously obtained in 1896 a piece of the same skin, which, it is known, was discovered by a party of Argentine surveyors during the preliminary studies for the boundary between Argentina and Chili in the Andean Cordillera, and, recognising also the importance of it, Dr. Erland Nordenskjöld went last year to the same spot to look for some more remains. The excavations which he made gave him, so far as I know, some bones, pieces of jaws, teeth, and claws of the same animal, but he did not obtain more remains of the skin.[1] My assistant, Mr. Hauthal, arrived later at the cave, when Dr. Erland Nordenskjöld had terminated his researches and commenced further exploration. He obtained, not only skulls, jaws, teeth, bones and claws, but also a nearly complete skin of the animal, which shows that it is a *Glossotherium*, together with bones of *Macrauchenia*, *Equus*, and *Auchenia*, also a great quantity of dung, hay cut by man, ashes, and some bones worked by man. I am not yet sure if the bones of man discovered by Mr. Hauthal were found in the same cave or in one of those in its neighbourhood; but the presence in the *Glossotherium* deposit of bones worked by man is a proof that man and other mammals, whose remains have been discovered in the cave, were contemporary. I suggest that the skin has been preserved by man for bedding. In the caves inhabited by ancient man in Patagonia I have seen cut hay, and probably this also was used for beds.

I expect to receive in a few days all these specimens at the same time as those of the *Miolania*, together with reports on the discoveries, and I think they will arrive in time for me to exhibit these remains at the meeting of the British Association at Dover.

The discovery made by Mr. Roth of some advanced Mammalia in the beds that contain dinosaurians, and Mr. Hauthal's discovery of remains of extinct vertebrates and other mammals in the caves of Southern Patagonia, associated with *Macrauchenia*, *Equus*, *Auchenia*, and man, are proofs of the very recent changes in the physical geography of Patagonia, and afford most

FIG. 2.—Reproduction of a photograph of the front view of skull, with the lower jaw, of *Miolania*, obtained in 1899, from Patagonia, by Mr. Santiago Roth, of the La Plata Museum, Argentine Republic (greatly reduced in size).

interesting problems, which can only be solved by a systematic examination of the Argentine country by experienced geologists. In the course of my paper on Patagonia, read before the Royal Geographical Society (May 29), I proposed that this Society, the Royal Society, and the British Museum, with other scientific institutions, should proceed to carry out these necessary investigations. These problems are not extraneous to the explorations which may be carried out by an Antarctic

[1] "E. Nordenskjöld, Neue Untersuchungen über *Neomylodon listai*, Zool. Anzeiger," vol. xxii. (1899) pp. 335–336.

expedition, and I think the new discoveries which I now communicate to the *Geological Magazine* may urge on the despatch of such expeditions as I propose. If these expeditions be made, how many changes may be produced in actual and general ideas on the age of the South American fossiliferous strata, on the disappearance of the lost southern lands, and on the affinities of extinct faunas so distant in time and space as those of South America and Australia!

## *MR. JOHN CORDEAUX.*

BY the death of Mr. John Cordeaux, ornithology loses, not only one of its most ardent votaries, but one who had pursued, if he did not strike out for himself, a line very different from that taken by most British lovers of birds. For nearly six-and-thirty years, as shown by a long series of contributions, chiefly to *The Zoologist*, he applied himself to the study of the phenomena of bird-migration, at first as exhibited on the coasts of Lincolnshire (in which county he lived) and Yorkshire. This led him in the autumn of 1874 to go to Heligoland for the sake of comparing notes with the now well-known Herr Gätke, whom, it is believed, he was the first British ornithologist to visit; and he soon after wrote for *The Ibis* (1875, pp. 172-188) a notice of the very wonderful collection formed by that naturalist on that island. In 1879 he joined Mr. Harvie-Brown (who had just communicated a remarkable paper to the Natural History Society of Glasgow) in a successful attempt to procure observations on migrating birds from the keepers of lighthouses and lightships on the coasts of England and Scotland; and in the following year, when the results of their inquiry were brought before the British Association at the Swansea meeting, he was named secretary of a committee appointed to continue systematically the scheme which they had shown to be practicable. Of this committee, which (with a slight variation of title) has since been annually reappointed, he has always been the hardworking secretary, and it is not too much to say that nearly all its success is mainly due to him. He not only arranged with the authorities for the distribution of the schedules, instructions, and other information necessary for the observers, but, by his own efforts, raised by subscription a large sum of money to meet the expenses of the inquiry, which proved to be far greater than had originally been anticipated. The time and trouble which all this involved were at first enormous; and, even to the last, the correspondence which he had to carry on was immense, yet his services were as willingly rendered as though he had been handsomely paid for them, instead of giving them gratuitously, and the way in which he contrived to interest the men at the lighthouses and lightships in the undertaking was marvellous. The results of this labour, continued without intermission for nine years, were partly shown by the admirable "Digest of the Observations," made by Mr. W. Eagle Clarke, which the committee was able to include in its report presented to the Association at Liverpool in 1896; and, as has been announced, that gentleman is still occupied in working out further details from the mass of materials that has been collected.

Mr. Cordeaux made more than one visit to Heligoland, and is understood to have been instrumental in bringing about the publication of an English translation of Gätke's celebrated work, though never committing himself to the adoption of his friend's views on many points. Indeed, he abstained on principle as much as possible from advocating any theories on the subject of migration, being convinced that much more knowledge had to be acquired from observation before more than a few first principles could be safely accepted. That he was the life and soul of the Migration Committee is beyond all doubt. His happy tact and sanguine temperament overcame all difficulties, though—especially from the financial point of view—they were at times so formidable as to threaten the abandonment of the work; yet by his care funds were always found to carry it on, eking out the successive and by no means illiberal grants of the British Association. He is said to have been very successful as a lecturer, and he often lectured on some ornithological subject, especially on the migration of birds, in the towns of Yorkshire and other parts of the country.

Forty papers are credited to Mr. Cordeaux in the Royal Society's Catalogue up to 1883, a number which might possibly be doubled now, and in addition to these he was the author of an unassuming but well-written little book, "Birds of the Humber District," published in 1872, a new edition of which it had been his intention to bring out. He died, after a short illness, at his residence, Great Cotes House, in Lincolnshire, on August 1, in the sixty-ninth year of his age, deeply lamented by all who had been associated with him in the work he so indefatigably carried out.

A. N.

## *NOTES.*

WE much regret to record that the serious illness of Prof. R. W. Bunsen, referred to in last week's NATURE, has ended fatally. An account of the chief work of this world-renowned chemist appeared nearly twenty years ago in our Series of Science Worthies (vol. xxiii.), and we hope to publish a further appreciation of the deceased investigator next week.

THE funeral of Sir Edward Frankland took place at Reigate on Tuesday. There were present, in addition to the immediate relatives, Sir Frederick Bramwell, Lord Lister, Sir Henry Roscoe, Sir Myles Fenton, Sir Michael Foster, Dr. Ludwig Mond, Dr. Thorpe, and others. The Rev. Prof. Bonney conducted the funeral service. Many wreaths adorned the coffin, including one from the Fellows of the Institute of Chemistry and one from the Chemical Society.

MAJOR RONALD ROSS, the leader of the expedition sent to Sierra Leone by the Liverpool School of Tropical Diseases to investigate the possibility of exterminating the malaria-bearing mosquito, has sent to Liverpool the following cablegram: "Malarial mosquito found. Ask Government to send at once men." Major Ross's observations in India indicated that the malaria parasite is borne by the spotted-winged mosquitoes, and not by the common brindled or grey mosquitoes; and his message announces that he has found that malaria on the West Coast of Africa is produced under the same conditions as in India. There is evidence that the malaria-bearing species only breeds in small isolated collections of water which can be easily dissipated, but the expedition has not yet had time to verify this point.

THE presence of bubonic plague in Portugal has been officially notified to the Local Government Board. Oporto has been declared to be infected, and the other ports of Portugal are considered suspected. Port sanitary authorities in this country have been instructed in the precautions to be observed to prevent the introduction or spread of the disease here.

IT is announced that Sir Edmund Antrobus is desirous of selling Stonehenge, the famous and mysterious monument on Salisbury Plain. Thinking it right that the nation should have the opportunity of purchasing this great relic of antiquity, the owner has offered it to the Government, with about 1300 acres of surrounding land (subject to certain pasturage and sporting rights), for the sum of 125,000*l.*

Prof. George Forbes, F.R.S., has just visited the Niagara Falls Company, and he describes in the *Times* the remarkable success which the Company has attained in the use of the Falls to develop electric energy. An enormous number of factories has been established on the Company's land, and they use between them no less than 34,590 horse-power. Additions are to be made in October, and two new works, the Atchison Graphite Company and the Lead Reduction Company (Litharge), will be supplied, bringing the total up to 45,190 horse-power contracted for, with an income of over 150,000*l.* The operating expenses do not exceed 25,000*l.* per annum. The result indicates, among other matters, the strides which have been taken of late years in electro-chemical and metallurgical processes. With regard to the machinery, the dynamos, which were totally new, not only in size but in their general design, never give the slightest trouble; and the transformers, ranging up to 2500 horse-power, have answered their purpose perfectly, even with the low trequency of alternations, which was generally condemned when Prof. Forbes introduced it, but is recognised now by every one at Niagara as contributing largely to the success of the scheme.

The Wellman Polar expedition, which left Tromsö, Norway, on June 26, 1898, returned there from Franz Josef Land on August 17, on the s.s. *Capella*, which took the party on board at Cape Tegetthof. Mr. Walter Wellman's intention was to make a rush to the North Pole. According to the Reuter telegram received on Saturday last, an outpost was established as far north as latitude 81°, and two men were left in it to spend the winter, while the main party returned to Cape Tegetthof (lat. 80°). In the middle of February last, in the depth of winter, Mr. Wellman, with three Norwegians and forty-five dogs, started northwards. On reaching the outpost the two men were found, but one had been dead for two months. Pushing northwards the party discovered land north of the Freeden Islands, where Nansen landed in 1895. In the middle of March, when all hands were confident of reaching latitude 87° or 88°, if not the Pole itself, Mr. Wellman, while leading the party, fell into a snow-covered crevasse, seriously injuring his leg, and the party was therefore compelled to retreat. Two days later they were roused at midnight by an earthquake, and in a few moments many dogs were crushed and sledges destroyed. Mr. Wellman's condition became alarming on account of inflammation, but his companions dragged him on a sledge, making forced marches for nearly 200 miles to the headquarters of the expedition, where they arrived early in April. The *Capella* arrived at Cape Tegetthof on July 27, and sailed homeward with the party on August 10. Though the expedition has thus ended in failure so far as reaching the North Pole is concerned, it is stated that important scientific observations have been made by Dr. Hoffmann (naturalist), Mr. Harlan (physicist), and Mr. W. B. Baldwin, of the U.S. Weather Bureau, who accompanied the expedition as meteorologist and second in command.

Prof. Balbiani has just died at Meudon at the age of seventy-five years. The following particulars of his career are given in the *Lancet:* As Professor of Comparative Embryology at the College of France he was formerly assistant to Claude Bernard at the Museum. Although descended from an Italian family he was born at Havana, and pursued his medical studies at Frankfort-on-the-Main before going to Paris. His reputation was world-wide, and he leaves a considerable number of works, of which the best known deal with the constitution of the egg, the embryonic vesicle, cellular division, the reproductive process in infusoria and aphides, and silkworm disease. He had been many times a laureate of the Institute, but, despite most pressing invitations on all hands, he never presented himself as a candidate at the Institute or Academy of Medicine where he would certainly have been elected. He wished only to be a member of the Society of Biology, of which he was one of the oldest and most industrious members. Besides, for many years past he did not himself lecture, but devoted his time more and more exclusively to the laboratory, leaving his lecture work to his assistant, Dr. Hennegy. Prof. Balbiani was, with Prof. Ranvier, editor of the *Archives d'Anatomie Microscopique.*

The *Times* correspondent at St. Petersburg announces that a new regulation on Russian weights and measures was officially published on August 18. The Russian pound is fixed as the standard of mass and declared to be equal to 409·512 grams, a pail or vedro is to hold 30 pounds of distilled water at 16°·6 C., and a garnietz 8 pounds of water. The unit of length is the arshin, equal to 71·12 centimetres. The metric system is to be optional, and may be used with the Russian in commerce in dealing with contracts, accounts, &c., and after mutual agreement by State and municipal authorities. Private persons are, however, to be under no compulsion to use the metric system when dealing with the above-named authorities.

The *Scientific American* states that the creation of a great national forestry and game preserve in northern Minnesota, embracing 7,000,000 acres around the headwaters of the Mississippi River, with many lakes of rare beauty, well stocked with fish, will be advocated before the U.S. Congress next winter by prominent citizens of Chicago and Minnesota. It is believed that the promoters of the plan will not experience much difficulty in interesting Congress. The game and the virgin forests of the United States are disappearing so rapidly that it is exceedingly important that measures be taken, before it is too late, to save some of the great wooded areas of the continent.

Under the auspices of the Philadelphia Commercial Museum and the Franklin Institute, a National Export Exposition for the advancement of American manufactures and the extension of the export trade will be held from September 14 to November 30. At the end of last year the U.S. Congress voted 350,000 dollars in support of the exposition, and other funds, amounting to 100,000 dollars, have been provided by the City Councils of Philadelphia and private subscriptions. The exposition grounds comprise a tract of land, fifty-six acres in extent, granted to the Philadelphia museums by the city of Philadelphia, and another tract of six acres secured for the uses of the exposition. Of the five structures comprising the main exhibition buildings three are permanent, but will only be completed at the present time sufficiently for the purposes of the exposition. These three permanent pavilions will have two stories. They will each be 380 feet long and 90 feet wide. The space between them will be covered by temporary buildings connected with the pavilions, the whole forming a single harmonious edifice. The permanent buildings will eventually become the home of the Philadelphia museums. One of the chief events to take place in connection with the exposition will be the International Industrial and Commercial Congress, which will assemble in Philadelpnia, beginning on October 10. A number of foreign Governments have accepted the invitation to send official envoys, and almost every city of the United States and Canada with a population over 10,000 will be represented by delegates from their Boards of Trade, Chambers of Commerce, &c. Of special interest to the members of the Franklin Institute will be the ceremonies in commemoration of the seventy-fifth anniversary of the Society, which will be held in one of the exposition buildings. The arrangements for this event contemplate a series of commemorative meetings,

beginning Monday evening, October 2, and occupying the entire week. The evenings of the week will be occupied successively by the Sections in the order of seniority, beginning with the Chemical Section.

A SERIES of six articles "by a Contributor," which appeared in the *Banffshire Journal*, has been reprinted as a pamphlet entitled "Prof. McIntosh on Trawling and Trawling Investigations: a criticism and analysis." It is written with evident detailed knowledge of the work of the Scottish Fishery Board, and of fishery matters in general. Prof. McIntosh's tables and statistics are carefully analysed—the object being to show that the conclusions in his book, "The Resources of the Sea," are invalidated by the errors which have crept in in the transcribing and re-arranging of an enormous mass of figures from the Annual Reports of the Fishery Board. The matter in dispute is of such importance that the Fishery Board for Scotland in their next report should definitely and authoritatively state whether or not they accept Prof. McIntosh's statements as to the results of the trawling experiments off the Scottish coast, and, if not, what grounds they have for arriving at a different conclusion.

THE Meteorological Council have published a valuable contribution to maritime meteorology, viz. Meteorological Charts of the Southern Ocean between the Cape of Good Hope and New Zealand. The region embraces latitude 30° to 60° S. and longitude 10° to 180° E., and the charts show, for each month of the year, the wind direction and force for areas of 3° of latitude by 10° of longitude, the barometrical pressure by isobars, temperature of air and sea by isotherms, and ocean currents, in addition to other useful data. The publication will add considerably to the information hitherto available for this part of the ocean, and will therefore be very serviceable to navigators. Introductory remarks draw attention to all the leading results shown by the charts, and to the broad features of the distribution of barometric systems and of air and sea temperature. In the preparation of this work, observations for each four hours have been extracted from about 2450 logs kept for the Meteorological Office or on board H.M. ships, being all that were available between the years 1855 and 1895, and also from numerous logs of private shipping companies.

"SYMONS's British Rainfall" (Stanford) for 1898 contains not only the usual statistics and conclusions referring to the distribution of rain over the British Isles last year, but also several articles of general meteorological interest. Thirty-five self-recording rain gauges have been described in previous volumes, and eight more are described in the present report, several of them being illustrated by diagrams showing the principles of construction. In an interesting note Mr. Symons tests the general proposition that the annual rainfall increases with the elevation of the locality above the sea, by applying it to the English lake district. The highest station considered was at Sca Fell Pike (3200 feet), and the lowest Greenside Mine (1000 feet). Grouping the stations according to altitude in zones differing by 500 feet, no sign of increase or decrease of rainfall with altitude was found—in fact, the lowest group (1000–1499 feet) and the highest (3000 upwards) had identical annual precipitations, viz. 99·3 inches. Moreover, the rainfall at twenty-nine stations having annual amounts of 100 inches or more were arranged according to precipitation, but little evidence was afforded of an increase with elevation, and many of the results point to a conflicting conclusion. For instance, Seathwaite (altitude 422 feet) has an annual rainfall of 135 inches, while at Seatoller Common (2000 feet) the fall is 126 inches; Dungeon Gill and Ullscarf have both the same fall, though the altitude of the former is 311 feet, while that of the latter is 2100 feet. Mr. Symons concludes: "All these cases show that altitude alone has little influence on the amount of rainfall, and that in a mountainous country attention should chiefly be directed to the trend of the hills and valleys in relation to the rain-bearing winds."

DR. HERGESELL, of Strassburg, has contributed to the *Illustrated Aeronautical Magazine* (No. 4, *Jahrgang* 1899) a mathematical investigation of the theoretical vertical movements of a free balloon. The subject engaged the attention of Mr. J. Glaisher in the *Encyclopaedia Britannica*, and is of considerable interest for scientific balloon navigation. The first case considered is that of the ascent of an imperfectly inflated balloon, and the formulæ give the velocity attained in a stratum of air of a definite density, *i.e.* at a definite altitude, and the time required in reaching this stratum. In the case of a perfectly inflated balloon, the investigation shows that the maximum height that can be attained depends entirely upon the lifting power, and that it is independent of the velocity of ascent, and of the resistance of the air. In the case of the descent of a balloon, it is shown that the velocity of the fall does not continually increase, as is often stated, but, on the contrary, decreases, and that there is no danger in allowing the balloon to descend from a great altitude without throwing out ballast, as the velocity of the descent decreases according to the greater height from which the descent is made.

M. J. LIPPMANN, writing in the *Journal de Physique* for August, proposes the adoption of an absolute measure of time based on the Newtonian constant of gravitation. The possibility of establishing such a unit depends on the property that the Newtonian constant is independent of the units of length and mass, and is of minus two dimensions in time; hence, by making the constant of gravitation equal to unity, an absolute unit of time is obtained which is found to be equal to 3862 seconds of mean time approximately. The afore-mentioned property, however, involves the assumption that the unit of mass is of the same dimensions as the unit of volume; in other words, that density is of no dimensions. Strictly speaking, M. Lippmann's time unit is of $-\frac{1}{2}$ dimensions in density, and therefore its value depends on the nature of the standard substance chosen as the unit of density. The proposal practically amounts to this: instead of adopting an astronomical unit of density (corresponding to the astronomical unit of mass) based on taking the mean solar second as unit of time, we are to adopt an absolute unit of time based on taking water as the unit of density.

THE *Atti dei Lincei* contains in recent numbers two somewhat closely allied papers on thermo-electricity. The first of these is a verification of the principle of thermodynamic equivalence for bimetallic conductors, by Signor Paolo Straneo, who concludes not only that thermo-electric phenomena proceed regularly in perfect accordance with theory, but that they can be studied with sufficient exactness by temperature-observations without having recourse to calorimetry. The determination of the Peltier-effect coefficient by the author's method succeeds even in the case in which previous methods are wanting in accuracy, namely, when the two metals possess a high specific resistance and a feeble Peltier-effect. With the present method, the Joule effect only slightly affects the phenomenon under consideration.

SIGNOR STRANEO's method forms the basis of a paper by Signor A. Pochettino on variations of the Peltier-effect in a magnetic field. The value of the Peltier-effect coefficient was observed to vary with the magnetisation. In Signor Pochettino's experiments, it increased up to a maximum value of 0·008968, corresponding to a field of ninety-eight units, and then decreased, reaching its normal value (0·008824) in a field of about 345 units, and continuing to decrease as the intensity of the field was further increased. The formula deduced from Houllevigue's experiments, combined with Thomson's formula,

only represents the phenomenon up to a field of 700 units. Lastly, the variation of the Peltier-effect coefficient is independent of the direction of magnetisation; in fact, in suitably-arranged experiments it is found that when the stationary temperature is attained, no changes take place in the thermal conditions of the conductors when the magnetising current is reversed.

In a report received by the Foreign Office, Sir William Garstin has called attention to the need for a scientific examination of the Sudan, with a view to the development of its natural resources. It is pointed out that a very possible source of future wealth to the Sudan lies in the vast forests which line the banks of the Upper Blue Nile and extend, in an easterly direction, to the Abyssinian frontier. In the Bahr-el-Ghazal province also, particularly in the Bongo country, large forest tracts exist. The ebony tree (*Dalbergia melanoxylon*) is met with south of Karkauj, on the Blue Nile, and again in the vicinity of the Sobat River. On the White Nile, in the Bongo and Rohl districts, the india-rubber creeper (*Landolphia florida*) is found in great profusion. If the rubber yielded by this creeper be not of quite so good a quality as that obtained from the Assam india-rubber tree (*Ficus elastica*), it is still of sufficient value to be counted as an important asset in the future trade of the Sudan. The Assam india-rubber tree should certainly flourish well in most parts of the Sudan, more particularly south of Khartoum. Although this tree takes from twenty to thirty years to arrive at a girth sufficient to permit of regular tapping, its yield is so valuable (about 3*l.* per tree per annum) that its introduction into the country is well worth attempting. It is very much to be hoped that a scientific examination of the Sudan forests may ere long be carried out under the superintendence of an expert. It is certain that much valuable information would be obtained from his report. Very little is known regarding the possibilities of mineral wealth in the Sudan. Until the country is more settled, an investigation of the mountainous regions of Kordofan and Darfur on the west, and of the Abyssinian frontier on the east, would be impossible. Iron ore is found in the Bahr-el-Ghazal province, and also in Darfur; while gold mines were at one time worked in the mountains south of Fazogl. Could coal be discovered, it would make a great change in the whole question of the Sudan. In a few years' time it is probable that the Geological Survey Department of Egypt will be able to depute parties to examine the Sudan. For the present, Sir William Garstin thinks nothing can be done.

"Variation and Sexual Selection in Man" is the title of a paper by E. Tenney Brewster in the *Proceedings* of the Boston Society of Natural History (vol. xxix., 1899, p. 45). The author offers evidence to prove that *conspicuous dimensions tend to be more variable than other dimensions*. Not only is the face more variable than the head, but the nose should be more variable than the head; the face without the nose should be more variable than the head; and the nose should be more variable than the rest of the face. The author also suggests that sexual selection has brought it about that parts of the body tend to be more variable in proportion as they are of greater æsthetic value.

The Report of the South African Museum for 1898, issued as a Parliamentary Paper, by the Director, Mr. W. L. Sclater, is satisfactory reading. It appears that in all departments the collections are steadily increasing; while great attention is being paid to the proper exhibition of suitable specimens. In the Geological Department a good collection of the rocks of the Kimberley mining district is already displayed; and steps are being taken for the formation of a complete collection of the economic mineral products of South Africa. This is as it should be; and it is equally satisfactory to learn that the Director is fully alive to the necessity of procuring specimens of all the larger mammals before it is too late. The collection of South African antelopes is indeed complete, with the exception of the Gemsbok and Lichi; and specimens of these ought not to be difficult to procure. It may be hoped that, in addition to the mounted specimens, a study series (if possible in duplicate) of skins may likewise be procured. The only subject the Director has to regret is that he has been unable, chiefly from lack of funds, to continue the work of preparing popular descriptive labels for the exhibited specimens. The hope is, however, expressed that the work may be shortly resumed.

As an excellent bit of work on the local distribution of a species, attention may be directed to Dr. N. H. Alcock's history of the Hairy-armed Bat in Ireland, published in the August number of the *Irish Naturalist*. In England this Bat is found rather abundantly along the Avon valley in Warwickshire, Worcestershire and Gloucestershire; it occurs rarely in Yorkshire, and has been recorded from Cheshire. In Ireland it has been found in most of the north-eastern counties, but nowhere else. We now want to know the reason of this very local distribution; and until this is ascertained our task is but half done.

M. E. Pitard describes in *l'Anthropologie* (x., 1899, p. 281) three crania from Swiss Lake sites. The first from Point, with an index of 91·5, belongs to the Rhetian or Dissentis type, and is remarkably similar to a skull described by M. Verneau from Concise, which that author believed to belong to the Bronze Age; but M. Pitard asserts that his example is Neolithic. The other two crania were found in the same layer at Concise, and are of the Bronze Age; their indices are 77·6 and 84·6.

The Vai or Vei are the only negroes who possess a true and indigenous writing. They occupy a territory on the confines of Sierra Leone and Liberia. The alphabet is syllabic, and it is the only syllabic alphabet existing in Africa. The first account of this remarkable language was published by Forbes and Norris in 1849, and Koelle also wrote on it in 1849 and 1854. Since then nothing has been published thereon till the recent study of M. M. Delafosse (*l'Anthropologie*, Tome x., 1899, pp. 129, 294). Forbes and Koelle asserted that the alphabet was invented about 1829 or 1839, but Delafosse considers it at least two hundred years old and perhaps older; it is not even certain that it was invented by the Vais themselves. Forbes was also wrong in stating that this alphabet was no longer in use in 1849; as a matter of fact, it is still increasingly employed. Of the 226 characters in the alphabet, 25 resemble Berber consonants in form, and 20 resemble European letters and numerals; but these may be purely superficial resemblances, as the sounds do not correspond: the author does not consider that the Vaï alphabet has been derived from these sources.

Sir J. Burdon-Sanderson asks us to notify the following errata in his MS. of the abstract of the Croonian Lecture published in Nature of August 10. On p. 344, col. 1, line 5, for "Fig. 1" read "Fig. 2"; col. 1, line 18, for "Fig. 2" read "Fig. 1"; col. 2, line 12 from the bottom, for "60" read "40."

Part xv. of Mr. Oswin A. J. Lee's elaborate work, entitled "Among British Birds in their Nesting Haunts," has been published by Mr. David Douglas, Edinburgh. The Part contains ten beautiful plates, illustrating the nesting places and nests of the whinchat, osprey, storm petrel, yellow bunting, rook pigeon, Manx shearwater, grey wagtail, and red grouse.

Herr Eugen von Cholnoky contributes to the *Verhandlungen der Gesellschaft für Erdkunde* a short summary of the scientific results of his journeys in China and Manchuria during 1896–98. The most important contributions refer to the geology of the regions visited, and in particular to the positions

of the great lines of faulting crossing Manchuria, indicated by Richthofen.

THE current number of the *Zeitschrift der Gesellschaft für Erdkunde* (vol. xxxiv, No. 2) is entirely devoted to the official reports of the members of the German deep-sea expedition in the *Valdivia*. Prof. Chun gives a narrative of the expedition and its progress; Dr. Gerhard Schott reports on the oceanographical work; and the navigating officer, Herr Walter Sachse, adds an account of the re-discovery of Bouvet Island. A summary of the contents of these reports has already appeared in these columns (p. 114).

A NUMBER of students from the Paris École Supérieure d'Electricité visited electrical works and manufactories in Switzerland at the end of last March, this being the second excursion arranged by the authorities of the School. A report upon some of the objects and installations examined was presented to the Société internationale des Électriciens in May, and has just been published as an excerpt from the *Bulletin* of the Society, by M. Gauthier-Villars, Paris.

THE additions to the Zoological Society's Gardens during the past week include a Vervet Monkey (*Cercopithecus lalandii*) from South Africa, presented by Mr. R. Hilliard; a Brown Capuchin (*Cebus fatuellus*, ♀) from Guiana, presented by Colonel Bourchier; a Common Kingfisher (*Alcedo ispida*), British, presented by Mr. John Porter; an Alexandrine Parrakeet (*Palaeornis alexandri*, ♀) from India, presented by Miss J. M. Pott; a Common Boa (*Boa constrictor*) from South America, presented by Mr. C. W. Lilley; an Alligator (*Alligator mississippiensis*) from Southern North America, presented by Commander H. Woodcock; two Grevy's Zebras (*Equus grevyi*, ♂ ♀) from Southern Abyssinia, a Malayan Bear (*Ursus malayanus*) from Malacca, deposited; three Pink-headed Ducks (*Rhodonessa caryophyllacea*, ♂ ♀ ♀) from India, six Edible Frogs (*Rana esculenta*), European; twelve Paradise Fish (*Macropus viridi-auratus*) from China, purchased; a Japanese Deer (*Cervus sika*), a Puma (*Felis concolor*), a Burchell's Zebra (*Equus burchelli*, ♀), born in the Gardens.

## OUR ASTRONOMICAL COLUMN.

HOLMES' COMET 1899 *d* (1892 III.).—

*Ephemeris for 12h. Greenwich Mean Time.*

| 1899. | R.A. | Decl. | Br. $r^{-2}$ | Br. $(r\Delta)^{-2}$ |
|---|---|---|---|---|
| | h. m. s. | ° ′ ″ | | |
| August 24 | 2 57 44·22 | +38 17 15·7 | 0·1888 | 0·04999 |
| 25 | 58 33·92 | 38 32 21·3 | | |
| 26 | 2 59 22 11 | 38 47 22·9 | | |
| 27 | 3 0 8·77 | 39 2 20·4 | | |
| 28 | 0 53·85 | 39 17 13·7 | 0·1869 | 0·05109 |
| 29 | 1 37·31 | 39 32 2 7 | | |
| 30 | 2 19·13 | 39 46 47·1 | | |
| 31 | 3 2 59 26 | +40 1 26 8 | | |

During the ensuing week the comet is in a good position for observation by observers having sufficient optical power; it passes closely to the south of the second magnitude variable star $\beta$ Persei (Algol).

THE PARIS OBSERVATORY.—The annual report of M. Lœwy, the director of the Observatory, contains a detailed review of the work accomplished during the past year.

Special attention has been devoted to the improvement of meridian observations, chiefly in the attempt to eliminate instrumental errors by greater precision and stability of the mountings.

The small equatoral coudé has been provided with several accessories, and the building covering it so altered that the whole is now adapted for astrophysical observations.

The volume of observations made during 1897 will shortly be published in four separate parts, by different authors, who will each be responsible for all reductions, descriptions and discussions contained in the part under their names.

The fourth part of the Paris Observatory Catalogue (of which the first three parts already published contain all the meridian observations made from 1837–1881) has just been completed. The meridian circles have been in use for fundamental observations, for a revision of Lalande's Catalogue, and for work on the variation of latitude.

*Coudé Equatorial.*—The large instrument has been chiefly used in obtaining further series of photographs of the moon (scale about 6·5 inches to the lunar diameter) for the large lunar atlas now in progress of publication. During the year 591 plates have been obtained for this purpose. The method of enlargement of the negatives has also been improved.

Accompanying the report is a heliogravure of the moon when 20d. 5·9h. old, reproduced the same size as the original plate.

For part of the year the photographic objective was replaced by the visual glass, and the instrument then used by M. Hamy for measuring the diameters of small celestial objects by an interference method. The satellites of Jupiter and the planet Vesta have been measured in this way, the diameter of the latter agreeing very closely with the value obtained by Prof. E. E. Barnard.

*Astrographic Equatorial.*—The actual photographic work is now almost completed, all that remains to be done being the replacement of a small number of defective plates. The reduction of the plates for the Catalogue is well in hand, and seven of the Chart plates have been engraved for heliographic reproduction.

"THE BULLETIN ASTRONOMIQUE."—The August number contains several interesting and suggestive articles.—M. Flammarion contributes an article on "The World of Jupiter," in which he discusses at length the question of the various rotation periods of the planet, and also an illustrated account of the observation made by M. Antoniadi at Juvisy during the opposition of June 1898.—"The Rotation of Venus" is treated mathematically by Abbé Th. Moreux, based on observations made at Juvisy by M. Antoniadi.—"Observations of Mars" (illustrated) are contributed by MM. V. Cerulli and J. Chloudoff.—MM. L. Rudaux and Em. Touchet furnish an article on the "Systematic Observation of Meteors," giving a suggested form for recording observations systematically, and dealing with the determination of radiants, the physical characters of the swarms, heights of the meteors, and the photographing of them.

THE SUN'S HEAT.—Prof. T. J. J. See contributes a further article dealing with the extension of Helmholtz's theory of the heat of the sun, in *Astr. Nach.* (Bd. 150, No. 3586). The method he now pursues is the determination of the potential of a heterogeneous sphere as caused by itself. He finds that the energy developed by the condensation on this assumption is greater than that produced in the condensation of a homogeneous sphere in the ratio of 176,868 to 100,000.

## IRON AND STEEL INSTITUTE.

THE autumn meeting of the Iron and Steel Institute was held this year at Manchester, on August 15 and 16, under the presidency of Sir William Roberts-Austen, K.C.B., and was attended by an unusually large number of members. The meetings were held in the Town Hall, the members being welcomed to Manchester in eloquent speeches by the Lord Mayor and by Mr. S. R. Platt, chairman of the Executive Reception Committee. In acknowledging the words of welcome, the President referred to the services rendered to metallurgy by Dalton and Joule, and by such great engineers as Fairbairn, Whitworth and Daniel Adamson, Manchester's distinguished sons. The programme was a long and varied one, no less than ten papers being on the list. The first read was by Prof. J. Wiborgh, of Stockholm, whose contribution, which was translated and read by Mr. H. Bauerman, dealt with the use of finely divided iron ore obtained by concentrating processes. By the introduction of such methods of separation, the power of enriching iron ores has been greatly increased; but the advantages are qualified by the circumstance that the product obtained is usually in the form of fine powder, which limits its utility to the smelter. The question of how such material can best be applied is one of importance, and the author shows how the material may be utilised by direct

addition to the charges in the blast furnace, by agglomeration previously to charging in the blast furnace, as a refining or softening material in the open-hearth furnace, and for the production of sponge iron for use in the open-hearth furnace.

Mr. H. C. McNeill next read a lengthy paper on some forms of magnetic separators and their application to different ores. The machines described were those invented by Wenström, by Delvik-Gröndal, by Heberle, and by Wetherill and the Monarch separator. Results obtained in practice in Sweden were discussed, and numerous illustrations were given. In the discussion of these two papers valuable remarks were made by Mr. James Riley, Mr. G. J. Snelus, F.R.S., Sir Lowthian Bell, Mr. Stead and others.

A new casting machine for blast furnaces was then described by Mr. R. H. Wainford. It is an ingenious apparatus for casting sandless pig iron in insulated moulds, so as to maintain a good crystalline fracture, equal to that of the pig iron made in sand beds, at a reduced cost of production. The advantages and disadvantages of this apparatus were discussed by Mr. E. Windsor-Richards, Mr. W. Hawdon, Mr. Cooper and Sir Lowthian Bell.

Mr. Syed Ali Bilgrami, Secretary to H.H. the Nizam's Government Public Works Department, Railways and Mines, then read a paper on the iron industry in Hyderabad. He described the geological structure of the Nizam's territory, and the various iron ore deposits met with.

Some interesting facts were brought forward by Major R. H. Mahon, of Cossipore, relating to the possibility of manufacturing at a profit iron and steel in India. In the absence of the author this paper was read by the Secretary, Mr. Bennett H. Brough. An interesting discussion followed, in which Mr. Bauerman and Mr. R. Price-Williams took part. The meeting was then adjourned until Wednesday, when a paper by Mr. C. H. Ridsdale was read. The microscopic examination of steel is a subject on which a good deal has been written during the last few years. Most of the papers hitherto published have dealt with the matter from a purely scientific point of view. The aim of the exhaustive paper contributed by Mr. C. H. Ridsdale was to show the practical value of the microscope to the steel maker and user at the present day. The time has now arrived, he points out, when it should be recognised that composition only indicates such well-defined effects as are generally understood without certain narrow limits of treatment, which are termed "normal." Outside these limits the effect of the treatment far outweighs that of the composition. In the discussion of this paper the President, Mr. Greiner, Mr. Harbord and Mr. Stead took part.

Mr. J. W. Miller contributed a paper on pig iron fractures and their value in foundry practice. He gave instances of the loss sustained by the manufacture of pig iron owing to the present method of grading pig iron by fracture.

The present position of the solution theory of carburised iron was discussed by Dr. A. Stansfield. The conclusions he has arrived at with respect to the atomic complexity in carbon are as follows:—

The carbon in molten iron is in a state of simple solution; the molecule of carbon must then contain one or two atoms, and is probably monatomic. The solidified iron is in the $\gamma$ state and contains free carbon in solution. The molecular weight of this carbon has not been discussed, but it is probably the same as that in the molten iron. The carbon in solid solution combines with iron, on cooling, to form a carbide, which is probably expressed by the formula $2(Fe_3C)$. When, on further cooling, this carbide falls out of solution as cementite, its formula may become more complicated; the solution theory affords no information on this point; but Sir W. Roberts-Austen stated in his presidential address that the nature of the products of its solution in acids led to the conclusion that the molecule may contain six atoms of carbon, and is at least as complex as would be indicated by the formula $6(Fe_3C)$. There appears to be a belief that the solution theory is in a sense opposed to, and has gone far to supplant, the older allotropic theory; but this paper will, it is hoped, effectually dissipate such an error, as it shows how entirely the solution theory of the relations of carbon and iron involves the allotropic changes with which the distinguished name of Osmond is so inseparably connected.

In the discussion of this paper Mr. Snelus, Mr. Hadfield and Mr. Stead took part.

Mr. A. Sauveur, of Boston, contributed a paper on the changes of structure brought about in steel by thermal and mechanical treatment. He showed that as the smaller the grains of the metal the more ductile and tough it will be, as the finest possible structure results from heating to Brinell's point W, the temperature at which the passage of cement carbon into hardening carbon during the heating of steel takes place, namely, 655° to 730° C., it is evident that every finished piece of unhardened steel should as a last treatment be heated to that temperature.

Prof. E. D. Campbell, of Ann Arbor, Michigan, contributed a paper on the constitution of steel. The general method employed for studying the products of steel was to dissolve the steel in hydrochloric acid, pass the gas evolved through bromine in order to convert unsaturated hydrocarbons of the general formula $C_nH_{2n}$ into their di-brom derivatives $C_nH_{2n}Br_2$; the gas passing through the bromine being measured, and the carbon existing as gaseous paraffins being determined by explosion and absorption of the carbon dioxide produced. The di-brom derivatives, after proper purification, drying, and weighing, were analysed and fractionally distilled for the purpose of qualitatively identifying the various constituents; although the fractional distillation of the di-brom derivatives had shown the presence of ethylene, propylene, butylene, pentylene, and hexylene di-bromides, and dibutylene tetrabromide, later investigations had shown that this last product was the result of the polymerisation under the influence of heat during distillation of butylene di-bromide, and was not present to any considerable extent, at least in the original derivatives. Although the di-brom derivatives from ethylene dibromide ($C_2H_4Br_2$) to hexylene dibromide ($C_6H_{12}Br_2$) had been detected qualitatively, the separation of the various derivatives by fractional distillation *in vacuo* was not sufficiently sharp to give accurate quantitative results in regard to the amount of each constituent present. From the percentage of bromine in the di-brom derivatives the average number of carbon atoms in the molecule was calculated, the results of the examination of a few samples of steel by the above method being shown in the following table:—

| Name. | Heat treatment. | Per cent. of carbon of steel. | Per cent. of carbon as derivatives. | Per cent. of carbon as gaseous paraffins. | Per cent. of carbon unaccounted for. | Per cent. of bromine in derivatives. | Calculated carbon atoms in carbon molecule of derivatives. |
|---|---|---|---|---|---|---|---|
| F | Annealed | 0·55 | 37·1 | 33·6 | 29·3 | 72·56 | 4·32 |
| F | Hardened and tempered | 0·55 | 25·0 | ... | ... | 75·65 | 3·67 |
| C | Annealed | 1·14 | 43·4 | 37·9 | 18·7 | 73·85 | 4·05 |
| C | Hardened | 1·14 | 29·0 | 48·6 | 22·4 | 77·61 | 3·31 |
| D | Annealed | 1·28 | 31·0 | 44·3 | 24·7 | 77·80 | 3·26 |
| | Pure Carbide from D anneal'd | 6·64 | 35·3 | 25·2 | 39·5 | ... | 4·41 |

The number of carbon atoms in the carbon molecule of the derivatives from the pure carbide, given in the above table, was obtained from the analysis of the gas by dividing the volume of carbon dioxide, produced from the explosion of the olefines, by the volume of the olefines exploded. The hypothesis suggested by the author made the fundamental assumption that carbon formed with iron a series of compounds which might properly be termed "ferrocarbons," on account of their similarity in structure to hydrocarbons. This series of ferrocarbons had the empirical formula $(CFe_3)_n$; or, $C_nFe_{3n}$, and should be considered as being derived from the hydrocarbons of the olefine series with the general formula $C_nH_{2n}$ by the replacement of the $H_2$ by the bivalent group $Fe_3$. These ferrocarbons, dissolved in hydrochloric acid, yield as their primary products of solution the corresponding olefines and hydrogen.

During the meeting excursions were arranged to the locomotive works at Horwich, to the Simon-Carves coke ovens near Barnsley, to the Manchester Ship Canal, to the ironworks of Platt Brothers, Ltd., at Oldham, to the boiler works of Galloways, Ltd., and to the steel works at Crewe; and hospitality was lavishly dispensed to the members by the Duke of Devonshire at Chatsworth, by the Lord Mayor of Manchester, and by the Mayor of Salford.

## MAGNETO-OPTIC ROTATION AND ITS EXPLANATION BY A GYROSTATIC SYSTEM.[1]

II.

I MUST now endeavour to give some slight account of the theories that have been put forward in explanation of magneto-optic rotation. There is an essential distinction between it and what is sometimes called the natural rotation, the plane of polarised light produced by substances, such as solutions of sugar, tartaric acid, quartz, &c., some of which rotate the plane to the right, some to the left. When light is sent once along a column of any of those substances without any magnetic field, its plane of rotation is rotated just as it is in heavy glass or bisulphide of carbon in a magnetic field. But if the ray, after passing through the column of sugar or quartz, is received on a silvered reflector and sent back again through the column to the starting point, its plane of polarisation is found to be in the same direction as at first. Quite the contrary happens when the rotation is due to the action of a magnetic field. Then the rotation is found to be doubled by the forward and backward passage, and it can be increased to any required degree by sending the ray backward and forward through the substance, as shown in this other diagram (Fig. 8).

Thus the rotations in the two cases are essentially different, and must be brought about by different causes. In fact, as was first, I believe, shown by Lord Kelvin, the annulment of the turning in quartz, and the reinforcement of the turning in a magnetic field, produced by sending the ray back again after reflection at the surface of an optically denser medium, points to a peculiarity of structure of the medium as the cause of the turning of the plane of polarisation in sugar solutions and quartz, and to the existence of rotation in the medium as the cause of the turning in a magnetic field. Think of an elastic solid, highly incompressible and endowed with great elasticity of shape and of the same quality in different directions—a stiff jelly may be taken as an example to fix the ideas. Now let one portion of the jelly have bored into it a very large number of extremely small corkscrew-shaped cavities, having their axes all turned in the same direction. Let another portion have imbedded in it a very large number of extremely small rotating bodies, spinning-tops or gyrostats in fact, and let these be uniformly distributed through the substance, and have their axes all turned in the same direction.

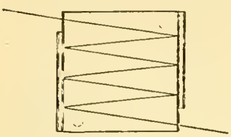

FIG. 8.

Both portions would transmit a plane-polarised wave of transverse vibration travelling in the direction of the axes of the cavities or of the tops with rotation of the plane of polarisation; but in the former case the wave, if reflected and made to travel back, would have the original plane of polarisation restored; in the latter the turning would be doubled by the backward passage.

To understand this it is necessary to enter a little in detail into the analysis of the nature of plane-polarised light. As I have already said, the elastic solid theory may not express the facts of light propagation, but only a certain correspondence with the facts. But its use puts this matter in a very clear way. In a ray of plane polarised light each portion of the ether has a motion of vibration in a line at right angles to the ray, and the direction of this line is the same for each moving particle. The lines of motion and the relative positions of the particles in a wave are shown in the first diagram (Fig. 1 p. 379). As the motion is kept up at the place of excitation, it is propagated out by the elastic resistance of the medium to displacement, and the configuration of particles travels outwards with the speed of light, traversing a wave-length (represented in the diagram by the distance between two particles of the row in the same phase of motion) in the period of complete to-and-fro motion of a particle in its rectilineal path.

Now, a to-and-fro motion such as this can be conceived as made up of two opposite uniform and equal circular motions. Think of two distinct particles moving in the two equal circles A B in this diagram (Fig. 9), with equal uniform speeds in opposite directions. Let each particle be at the top of its circle at the same instant; then at any other instant they will be in similar positions, but one on the right, the other on the left of the vertical diameter of the circle. Thus at that instant each particle is moving downward or upward at the same speed, while with whatever speed one is moving to the left, the other is moving with precisely that speed towards the right. Imagine now these two motions to be united in a single particle. The vertical motions will be added together, the right and left motions will cancel one another, and the particle will have a motion of vibration in the vertical direction of range equal to twice the diameter of the circles, and in the period of the circular motions.

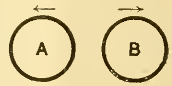


FIG. 9.

The rate of increase of velocity of the particle at each instant is the resultant obtained by properly adding together the accelerations of the particles in the circular motions, and therefore the force which must act on the particle to cause it to describe the vibratory motion just described is the resultant of the forces required to give to the two particles the circular motions which have just been considered.

Now, what we have done for any one particle may be conceived of as done for all the particles in a wave. To understand the nature of a wave in this scheme, we must think of a series of particles originally in a straight line in the direction of propagation of the ray, as displaced to positions on a helix surrounding that direction. Fig. A of this diagram (Fig. 10), regarded from the lower end, and the black spots on the model before you, show a left-handed helical arrangement. Let these particles be projected with equal speeds in the circular paths represented by the circle at the bottom of Fig. A. On this circle are seen

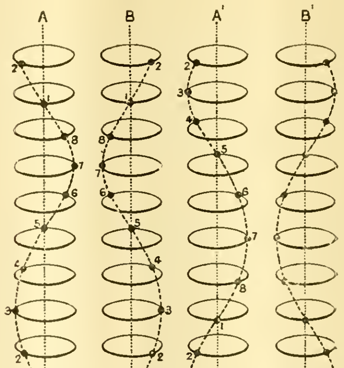


FIG. 10

the apparent positions of different particles in the helical arrangement when it is viewed by an eye looking upwards along its axis. This motion is shown by that of the black spots on the surface of the model (Fig. 11), when I set it into rotation about its axis. Let the particles be constrained to continue in motion exactly in this manner. As the model shows, the helical arrangement of the particles is displaced along the cylinder. This is the mode of propagation of a *circularly* polarised wave, which is made up of helical arrangements of particles which were formerly in straight lines parallel to the axis.

The direction of propagation of the wave is clearly from the

[1] A discourse delivered at the Royal Institution by Prof. Andrew Gray, F.R.S. (Continued from p. 381.)

bottom of the diagram to the top, and from the end of the model towards your left to the other, when the particles have a right-handed motion, and is in the contrary direction when the direction of rotation is reversed. For a right-handed helical arrangement the direction of propagation for the same direction of motion of the particles is the opposite of that just specified. The direction of propagation remains, therefore, the same when the direction of motion and the helical arrangement of the particles are both reversed. All this can be made out from the diagram. Fig. B shows part of a right-handed arrangement of

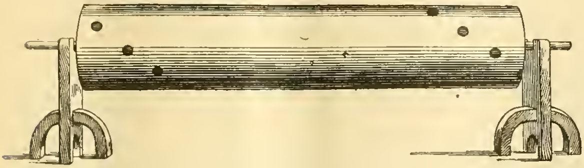

FIG. 11.

particles corresponding to the opposite arrangement of Fig. A; and if the particles have the motions shown at the bottom of the diagram the propagation will be for both in the same direction, from the bottom to the top.

In Fig. 10 we suppose the periods equal and also the wave-lengths, the distance along the axis from particle 1 to particle 9. The combination of the circular motions A and B gives rectilinear motion; the combination of the wave motions of Figs. A and B gives a plane polarised wave the plane of polarisation of which does not change in position. If, however, while the periods were equal, the wave-lengths were unequal as shown in this other diagram (Fig. 12), the plane of polarisation would rotate, as shown by the lines drawn across the paths in the figure on the right, for the circular motions of particles in the longer wave would gain on those in the shorter.

A little consideration will show that the direction of the resultant rectilinear motion will, in consequence of the unequal speeds of propagation, turn round as the wave advances, and will do so in the direction of motion of the particles in the more quickly travelling wave, generating the screw surface shown in the model I have already exhibited.

We must now consider the forces. The particles moving in the circular paths have accelerations towards the centres of these paths, and forces must be applied to them to produce these accelerations. These forces are applied in the present theory by the action of the medium, and it is the reactions of the particles on the medium that are properly called the centrifugal forces of the particles. The requisite centreward forces then are supplied by the state of strain into which the medium is thrown by the displacement of parts of it, which form in the undisturbed position a series of straight arrays in the direction of propagation, into these helical arrangements round that direction. The greater these elastic forces the greater the velocity of propagation of the wave.

In an elastic medium these forces depend on the *amount* of the relative displacements of the particles, and will be greater for displacements in the right-hand helical arrangement than for displacements in the opposite direction if the medium has a greater rigidity for right-handed distortion than for left, and the right-handed wave of distortion will be transmitted with greater speed, and *vice versâ*. This is the case of solutions of sugar and tartaric acid, quartz, &c., for which a helical structure has been supposed to exist in the medium.

Taking this case refer to Figs. A and B of our large diagram (Fig. 10), and let the right-handed wave travel the faster. Let the waves travel up, be reflected at the upper ends, as at the surface of a denser medium, and then travel down again. The reflected waves are those shown in Figs. A′, B′ of the diagram. By the reflection, the helical arrangement will be unaltered. But the plane of polarisation, as we have seen, turns round in space in the direction of the motion of the particles in the more quickly moving wave; it therefore turns round in the direction of the hands of a watch as the wave moves in the upward direction in the diagram, and in the opposite direction when the wave is travelling back. Thus the rotation of the plane of polarisation produced in the forward passage is undone in the backward.

It is easy to see that the same thing will take place if the reflection is at the surface of an optically rarer medium, so that the direction of motion of the particles is the same in the reflected as in the direct wave. The helical arrangements, however, are reversed by the reflection, and hence the wave which travelled the more quickly forward travels the more slowly back, and again the turning of the plane of polarisation is annulled by the backward passage. Thus Lord Kelvin's hypothesis of difference of structure completely explains the phenomena.

We pass now to the other case, that of magneto-optic rotation. Let us suppose, to fix the ideas, that the right-handed circular ray travels faster than the other, and that whether direct or reversed. Here, as in the other case, the elastic reaction of the medium on the displaced particles depends only on the distortion, and if there be no structural peculiarity in the medium there must be the same reaction in the particles in both the circular waves which combine to make up the plane-polarised one.

Thus the actions on the particles being the same for both waves, and the velocities of propagation being different, the motions concerned in the light propagation cannot be the same. There must in fact be a motion already existing in the medium which, compounded with the motions concerned in light propagation, give two motions which give equal reactions in the medium against the equal elastic forces, applied to the particles in the case of equal helical displacements.

Thus Lord Kelvin supposes that in the medium in the magnetic field there exists a motion capable of being compounded

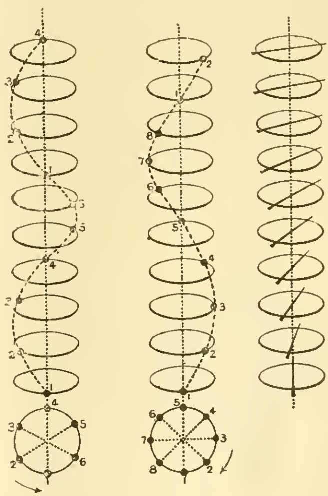

FIG. 12.

with the luminiferous motion of either circularly polarised beam. The latter is thus only a component of the whole motion.

In the very important paper in which he has set forth his theory Lord Kelvin expresses his strong conviction that his dynamical explanation is the only possible one. If this view be correct, Faraday's magneto-optic discovery affords a demonstration of the reality of Ampère's theory of the ultimate nature of magnetism. For we have only to consider the particles of a magnetised body as electrons or groups of charges of electricity, ultimate as to smallness, rotating about axes on the whole in

alignment along the direction of the magnetic force, and with a preponderance of one of the two directions of rotation over the other. Each rotating molecule is an infinitesimal electromagnet, of which the current distribution is furnished by the system of convection currents constituted by the moving charges.

The subject of magneto-optic rotation has also been considered by Larmor, and two types of theory of these effects have been indicated by him in his report on the "Action of Magnetism on Light." One is represented by Lord Kelvin's theory, which is illustrated by Maxwell's chapter on molecular vortices in his "Electricity and Magnetism." FitzGerald's paper "On the Electromagnetic Theory of the Reflection and Refraction of Light," in the *Philosophical Transactions* for 1880, is related to Maxwell's theory, and explains the rotation produced by reflection from the pole of a magnet by means of the addition of a term to the energy of the system. The other theory is also a purely electromagnetic one, and supposes that the effects are due to a kind of æolotropy of the medium set up by the magnetisation, and so attributes them to a change of structure which introduces rotational terms into the equations connecting *electric* displacements and electric forces. This latter theory therefore regards the magneto-optic rotation as only a secondary effect of the magnetisation, which is not supposed to exert any direct dynamical influence on the transmission of the light-waves.

It is not possible here to enter into the subject of these theories, but I should like to direct attention to a paper by Mr. J. G. Leathem, published in the *Philosophical Transactions*, in which the type of theory just referred to has been worked out and compared in its results with the experiments of Sissingh and Zeeman in reflection. These investigators made measurements of the phase and amplitude of the magneto-optic component of the reflected light for various angles of incidence. For both these quantities the theoretical results of Leathem agree very well with the observed values.

Returning now to the gyrostatic medium, between which and the electromagnetic theory, it is to be remembered, there is a correspondence, we may inquire in what way the gyrostats, when moved by the vibrations of the medium, react upon it, and so affect the velocity of propagation. The motion of a gyrostat is often regarded as mysterious, and it can hardly be fully explained except by mathematical investigation. But the general nature of its action may be made out without much difficulty. First of all, a gyrostat consists of a massive fly-wheel running on bearings attached to a case which more or less completely encloses the wheel. The mass of the wheel consists in the main of a massive rim, which renders as great as possible what is called the moment of momentum of the wheel when rotating about its axis. The diagram (Fig. 13) represents a partial section of the case and fly-wheel of a gyrostat, showing the arrangement of fly-wheels and bearings.

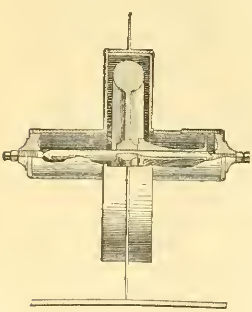

FIG. 13.

Now let the fly-wheel of such a gyrostat be rapidly rotated, and the gyrostat be hung up as shown in this other diagram (Fig. 14), with the plane of the fly-wheel vertical, and a weight attached to one extremity of the axis. The gyrostat is not tilted over, but begins to turn round the cord by which it is suspended with a slow angular motion which is in the direction of the horizontal arrow, if the direction of rotation is that of the circular arrow shown on the case. The same thing is shown by the experiment I now make. I spin this gyrostat and hang it with the axis of rotation horizontal by passing a loop of cord round one end of the axis so that the weight of the gyrostat itself forms the weight tending to tilt it over about the point of suspension. The axis of rotation here again remains nearly horizontal, but turns slowly round in a horizontal plane as before.

The explanation in general terms is this. The weight gives a couple tending to turn the gyrostat about a horizontal axis at right angles to that of rotation. This couple in any short interval of time produces moment of momentum about the axis specified, the amount of which is the moment of the couple multiplied by the time, and may be represented in direction and magnitude by the line OB. This must be compounded with the moment of momentum OA already existing about the axis of rotation, and gives for the resultant moment of momentum the line OC, which is the direction of the axis of rotation after the lapse of the short interval of time. The axis of rotation thus turns slowly round in the horizontal plane, and the more slowly the more rapidly the fly-wheel rotates.

The gyrostat in fact must have this precessional motion, as it is sometimes called, in order that the moment of momentum of the gyrostat about a vertical axis may remain zero. That it must remain zero follows from the fact that there is no couple in a horizontal plane acting on the gyrostat.

Thus any couple tending to change the direction of the axis in any plane produces a turning in a perpendicular plane. For example, if a horizontal couple, that is about a vertical axis, were applied to the axis of the gyrostat in the last figure it would turn about a horizontal axis, that is, would tilt over.

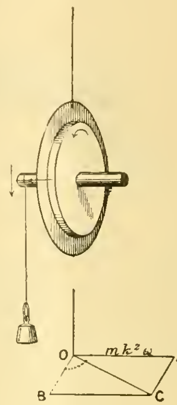


FIG. 14

Again, consider a massive fly-wheel mounted on board ship on a horizontal axis in the direction across the ship. The rolling of the ship changes the direction of the axis, and produces a couple applied by the fly-wheel to the bearings and an equal and opposite couple applied by the bearings to the fly-wheel. This couple is in the plane of the deck, and is reversed with the direction of rolling, and has its greatest value when the rate of turning of the ship is greatest. Thus the force on one bearing is towards the bow of the ship, the force on the other towards the stern, during a roll from one side to the other; and these forces are reversed during the roll back again. This is the gyrostatic couple exerted on its bearings by the armature of a dynamo on shipboard.

In the same way, when a gyrostat is embedded in a medium and the medium is moving so as to change the direction of the axis of rotation, a couple acting on the medium in a plane at right angles to the plane of the direction of motion is brought into play. To fix the ideas, think of a row of small embedded gyrostats along this table with their axes in the direction of the row, and their fly-wheels all rotating in the same direction. Now let a wave of transverse displacement of the medium in the vertical direction pass along the medium in the direction of the chain. The vibratory motion of each part of the medium will turn the gyrostatic axis from the horizontal, and thereby introduce horizontal reactions on the medium. Again, a wave of horizontal vibratory motion will introduce vertical reactions in the medium from the gyrostats.

Now, a wave of circular vibrations, like those we have already considered, passing through the medium in the direction of the chain, could be resolved into two waves of rectilinear vibration, one in which the vibration is horizontal, and another in which the vibration is vertical, giving respectively vertical and horizontal reactions in the medium. The magnetisation of the medium is regarded as due to the distribution throughout it of a multitude of rotating molecules, so small that the medium, notwithstanding their presence, seems of uniform quality. The molecules have, on the whole, an alignment of their axes in the direction of magnetisation. These reactions on the medium when worked out give terms in the equations of wave propagation of the proper kind to represent magneto-optic rotation.

It is worthy of mention that the addition of such terms to the equation was made by McCullagh, the well-known Irish mathematician, who, however, was unable to account for them by any

physical theory. The necessary physical theory may be regarded as afforded by the mechanism which thus forms an essential part of Lord Kelvin's mode of accounting for magneto-optic effects.

Lord Kelvin, in his Baltimore Lectures, has suggested for magneto-optic rotation a form of gyrostatic molecule consisting, as shown in the figure, of a spherical sheath enclosing two equal gyrostats. These are connected with each other and with the case by ball-and-socket joints at the extremities of their axes, as shown in Fig. 15. If the spherical case were turned round any axis through the centre no disalignment of the gyrostats contained in it would take place, and it would act just like a simple gyrostat. If, however, the case were to undergo translation in any direction except along the axis, the gyrostats would lag behind, and the two-link chain which they form would bend at the centre. This bending would be resisted by the quasi-rigidity of the chain produced by the rotation, and the gyrostats would react on the sheath at the joints with forces as before at right angles to the plane in which the change of direction of the axis takes place.

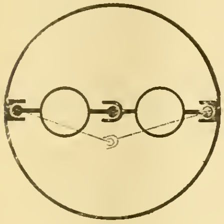

FIG. 15.

The general result is, that if the centre of this molecule be carried with uniform velocity in a circle in a plane at right angles to the line of axes, the force required for the acceleration towards the centre, and which is applied to it by the medium, is greater or less according as the direction in which the molecule is carried round is with or against the direction of rotation of the gyrostats. That is, the effect of the rotation is to virtually increase the inertia of the molecule in the one case and diminish it in the other.

These molecules embedded in the medium are supposed to be exceedingly small, and to be so distributed that the medium may, in the consideration of light propagation, be regarded as of uniform quality. Lord Kelvin's last form of molecule, it may be pointed out, if the surface of its sheath adheres to the medium, will have efficiency as an ordinary single gyrostat as regards rotations of the molecule, and efficiency likewise as regards translational motion of the centre of the molecule. The former efficiency can be made as small as may be desired by making the molecule sufficiently small; the latter may be maintained at the same value under certain conditions, however small the molecule be made.

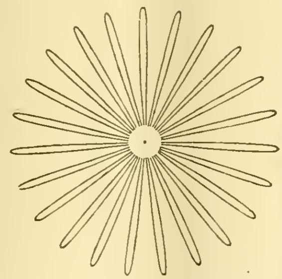

FIG. 16.—Path of the Bob of a Gyrostatic Pendulum. As the pendulum moves, it passes from one ray to another on the opposite side, and the direction of motion at each swing alters through the angle between two rays. The central parts of the rays are left out. The marking point does not pass exactly through the centre.

The lately discovered effect of a magnetic field in giving one period of circular oscillation of a particle or another according as the particle is revolving in one direction or the other about the direction of the magnetic force, is connected with magneto-optic rotation. There is a connection between velocity of propagation and frequency of vibration, which is exemplified by the phenomena of dispersion. In the Faraday effect, the two modes of vibration, if of the same period, have different velocities of vibration, consequently these two modes of vibration must have different frequencies for the same velocity of propagation.

The vibrations of the molecules of a gas in which the Zeeman effect is produced by a magnetic field may be represented by the motion of a pendulum the bob of which contains a rapidly rotating gyrostat with its axis in the direction of the supporting wire of the pendulum. The period of revolution of the bob when moving as a conical pendulum is greater or less than the period when the gyrostat is not spinning according as the direction of revolution is against or with the direction of rotation.

The bob when deflected and let go moves in a path which constantly changes its direction, so that if a point attached to the bob writes the path on a piece of paper, a star-shaped figure is obtained. I cause the gyrostatic pendulum here suspended to draw its path by a stream of white sand on the black board placed below it, and you see the result.

I must here leave the subject, and may venture to express the hope that on some other occasion some one more specially acquainted with the electromagnetic aspects of the phenomenon may be induced to place the latest results of that theory before you.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

MR. JAMES BROWN THOMSON, of Kinning Park, Glasgow, who died ten months ago, left 80,000*l.* to Glasgow institutions—mostly educational and benevolent. The Glasgow University will receive 10,000*l.*

THE recent discussion in NATURE on "The Duties of Provincial Professors" forms the subject of a short critique in the August number of the *Educational Review*. While fully endorsing the general views expressed in our columns, the *Review* remarks: "There is only one flaw in the indictment—the insinuation, namely, that university professors should take no part in the social life and physical activities, the general discipline, the corporate existence of the university or university college." But where does this flaw exist? No such insinuation is made in the article in NATURE.

THE Department of Science and Art has issued the following list of successful candidates for Royal Exhibitions, National Scholarships, and Free Studentships (Science) awarded this year:—Royal Exhibitions: William M. Selvey, Edward C. Moyle, Archibald D. Alexander, Charles W. Price, George F. A. Cowley, Edgar Sutcliffe, Sydney A. Edmonds. National Scholarships for Mechanics: Francis P. Johns, George F. Turner, Walter A. Scoble, Arthur J. Spencer, William H. Adams. Free Studentships for Mechanics: R. Borlase Matthews, William H. Outfin. National Scholarships for Physics: William R. Daniel, William J. Lyons, James Lord, William M. Varley, Wilfred H. Clarke. Free Studentships for Physics: John H. Shaxby, Gerald Henniker. National Scholarships for Chemistry: William D. Rogers, John H. Crabtree, Howard E. Goodson, Arthur H. Higgins, Montague W. Stevens. Free Studentships for Chemistry: John R. Horsley, Arthur C. Nicholson. National Scholarships for Biology: Eric Drabble, Louis E. Robinson, Ernest A. Wraight, Reginald F. G. Bayley, Harold B. Fantham. National Scholarships for Geology: William H. Goodchild, Thomas Thornton.

THE following list of candidates, successful in this year's competition for the Whitworth Scholarships and Exhibitions, has been received from the Department of Science and Art:—Scholarships, tenable for three years, 125*l.* a year each: Alec W. Quennell, London; Hanson Topham, Great Horton, Bradford; William V. Shearer, Langside, Glasgow; George Wall, Oldham. Exhibitions, tenable for one year, value 50*l.* each: Arthur J. Spencer, Portsmouth; George F. Turner, Sheffield; Harold P. Philpot, London; William H. Adams, Devonport; Edward C. Moyle, Devonport; Walter A. Scoble, E. Stonehouse, Devon; Archibald D. Alexander, Portsmouth; Sydney A. Edmonds, Devonport; George F. A. Cowley, Portsmouth; Albert Wilson, Leeds; Edwin J. Britton, Portsmouth; Harry Duncan, Plumstead; Samuel C. Rhodes, Morley, Leeds; Harry M. Andrew, Manchester; Alexander P. Traill, North Shields; Leonard Bairstow, Halifax; William T. S. Butlin, Bristol; Albert E. Dodridge, Devonport; James Lowe, Alloa; William J. Rodd, Plumstead; Francis C. Rendle, Plymouth; Thomas E. Heywood, Cardiff; James Paul, Woolwich; Charles P. Raitt, Portsmouth; Charles H. Booth, Bolton; Edward Howarth, Oldham; Percy Down, London; Marshall H. Straw, Sneinton, Nottingham; R. Borlase Matthews, Swansea; Samuel Crossley, Oldham.

## SOCIETIES AND ACADEMIES.

EDINBURGH.

**Royal Society**, July 17.—The Hon. John Abercromby in the chair.—The Keith prize for the period 1895–97 was awarded to Dr. Thomas Muir, for his valuable mathematical papers published in the *Transactions* and *Proceedings*. The Makdougall-Brisbane prize for the period 1896–98 was awarded to Dr. William Peddie, for his experimental researches on the torsion of wires, his discussion of a unique case of colour-blindness, and other investigations in physical science. The Neill prize for 1895–98 was awarded to Prof. Cossar Ewart, for his important investigations bearing on the theory of heredity.—A paper by Lord Kelvin, on magnetism and molecular rotation, was communicated, the main conclusion of which was that a gyrostatic molecule could not in a strong magnetic field give the Zeeman effect. Only a broadening of the lines, not a splitting, could occur. This agreed with Larmor's statement; and the probability was that Lorentz's theory was essentially true.—Sir John Murray and Mr. F. P. Pullar read a first instalment of their account of a bathymetrical survey of the Scottish fresh-water lochs. These could be divided into two great classes, the deep and the shallow. The shallow lochs varied considerably in temperature throughout the year—a fact which had an important bearing on the forms of animal life frequenting these lochs. The lochs discussed were Lochs Katrine, Arklet, Achray, Vennacher, Drunkie, Voil, Doine, and Lubnaig. 2422 soundings had been taken. The greatest depth observed in Loch Katrine was 495 feet; and about one square mile of the bottom of this loch was below sea level. The portable sounding machine used had been designed by Mr. Pullar.—Dr. Hepburn exhibited a new osteometric board, the idea of which was to keep the vertical sliding piece always perfectly parallel to itself. This was effected by means of two brass rods parallel to each other and parallel to the graduated board. These passed through holes in the vertical sliding piece. By this simple device all irregularities in successive measurements of the same bone were quite done away with.

PARIS.

**Academy of Sciences**, August 14.—M. Maurice Lévy in the chair.—Researches on the metallic derivatives of acetylene, by MM. Berthelot and Delépine. Thermochemical experiments on the compounds of acetylene with silver, silver nitrate, silver sulphate, silver chloride and iodide. Dry silver acetylide, $Ag_2C_2$, detonates when heated in a vacuum with production of a reddish flame. The authors discuss the nature of this explosion, since the products being solids, silver and carbon, no flame would be expected. The conclusion is arrived at that the temperature of the reaction is sufficient to volatilise the carbon, and that the flame is gaseous carbon at a very high temperature approaching 4000° C.—Reaction of argon and nitrogen with mercury alkyls, by M. Berthelot. Mercury methyl, $Hg(CH_3)_2$, submitted in an atmosphere of argon to the action of the silent electric discharge, forms no compound with argon, although when the argon is replaced by nitrogen the latter is readily absorbed. With mercury phenyl, $Hg(C_6H_5)_2$, a slight absorption of argon is noticeable, amounting to about 5 per cent. in twenty-three hours.—Observations of Tempel's Comet (1873 II.), made at the Observatory of Paris (with the 30·5 centimetre equatorial), by M. G. Fayet. The observations were carried out on the nights of July 31, August 9 and 10. The comet was at its brightest on July 31, although very low down on the horizon.—Observations of the Perseids of 1899, by Mlle. D. Klumpke. These observations were made under very favourable conditions of sky between August 9 and 13.—On the shower of shooting stars (Perseids) at Lyons, and a remarkable meteor, by M. Ch. André. The August showers of shooting stars were relatively small in number at Lyons. On the evening of the 11th a remarkable meteor was seen starting at about 10·43 p.m. from the constellation of Hercules. It was bluish-white at first, changing abruptly in colour to an orange-red. It was under observation for four seconds.—On the correspondence between right lines and spheres, by M. O. E. Lovett.—On the black pottery earths, by M. H. Le Chatelier. The property of producing black ware by the action of air charged with tar vapour at a high temperature is found to be intimately related with the presence of iron in the earth; in the absence of iron, a greyish coloration at the most is produced in the interior, nearly all the carbon remaining in the outside crust. The most satisfactory results were obtained by acting with acetylene for a quarter of an hour at 450° to 480° upon an earth containing about 2 per cent. of iron oxide. The objects are then removed to a furnace and baked at about 1200°, the hardness thus obtained being comparable with that of porcelain.—On Egyptian porcelain, by M. H. Le Chatelier.—Action of sodammonium and potassammonium upon tellurium and sulphur, by M. C. Hugot. With the alkali in excess the products were $Na_2S$, $K_2S$, $Na_2Te$, $K_2Te$, all white amorphous substances, soluble in water, but insoluble in liquid ammonia, and incapable of absorbing ammonia. With the sulphur or tellurium in excess, the products are $Na_2S_5$, $K_2S_5$, $Na_2Te_3$, $K_2Te_3$, all crystalline, soluble in water and in liquid ammonia, and capable of absorbing ammonia gas.—On the composition of the albumen of the seed of the carob tree, by MM. Em. Bourquelot and H. Hérissey. It has been shown in a previous paper by the authors that a mixture of mannose of galactose results from the careful hydrolysis of the albumen from carob seeds. It is now found that four-fifths of this albumen is constituted by a mixture of the anhydrides of mannose and galactose (mannane and galactane). The carob seed is a very advantageous source of crystallised mannose.—Detection and estimation of free phosphorus in oils and fatty bodies, by M. E. Louïse. The oil or fat is dissolved in twenty times its volume of ordinary acetone, and a concentrated solution of silver nitrate added. The silver produced is assumed to be proportional to the amount of free phosphorus present.—On the coloration of the Tunicates and the mobility of their pigmentary granules, by M. Antoine Pizon.—Action of different luminous radiations upon silkworms in different stages, by M. C. Flammarion.

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THURSDAY, AUGUST 31, 1899.

## PLANTS AND THEIR ENVIRONMENT.

*Les Végétaux et les Milieux Cosmiques (Adaptation–Evolution).* Par J. Constantin. Pp. 292. Avec 171 gravures dans le text. (Paris: Félix Alcan, 1898.)

THIS little book has some admirable points which can be urged in its favour, and it also exhibits lacunæ which are a source of irritation to the reader. Chief amongst its more obvious defects is the entire lack of reference to literature. In a book of this sort such references are particularly desirable, as it will be read by many who may have no special first-hand acquaintance with the sources whence M. Constantin draws his facts.

The book is well conceived and clearly written, though of course it makes no claims to be considered as an exhaustive treatise.

The various kinds of surroundings in which different plants live, and the nature of the corresponding response on the part of the plant organism forms the main thesis of the book. An example will serve to illustrate the author's method.

The cold temperate climate on the whole tends to favour the production of dwarf plants, whereas the colder seas, as is well known, are the home of the largest algæ. Ultimately both of these apparently contradictory effects are to be explained on nutritional grounds, the short period of terrestrial vegetation, during which alone assimilation can proceed, is to be contrasted with the more equable temperature of the sea, and especially with the fact that nutrition is favoured, in the case of aquatics, by lower temperatures, since gases are more soluble, and hence more abundantly at the disposal of the organism, than would be the case in warmer water.

Similarly, the effects of light, gravity and aquatic surroundings upon the structure and form of plants are discussed, and the reader will find much to interest him in the pages which deal with these topics. At the same time it must be confessed that the treatment strikes one as somewhat superficial at times, especially when the author wanders into the paths of theoretical interpretation.

M. Constantin shares the belief, emphatically held by some German botanists, in the direct influence of the environment not only as modifying the form in the individual but also as impressing, without the aid of natural selection, that form on the species as part of its inherited stock; and one chapter is devoted to an attempt to establish the thesis that acquired characters are inherited. As usual, however, in such cases, the meaning of "acquired characters" is not rigidly defined, nor separated from latent possibilities in the organism which the environment is able to emphasise simply by providing that stimulus which ensures their positive appearance.

Some of these variations, responsive to the external requirements, are certainly very difficult of explanation on the doctrine of selection, but the opponents of this theory sometimes seem to overlook the fact that, in the first place, it is not in the least necessary to assume that variations will be *slight*; they are often, on the contrary, in the case of specially plastic individuals, very extensive when these are subjected to a change of environment. And, in the second place, it is not necessary to suppose that any given species, and far less any individual, will vary equally in different directions round its average or mean. A very slight acquaintance with horticultural operations is enough to convince any one that certain races are specially plastic as regards one organ, whilst in others modification is most easily provoked in a different one. And selection, acting as it essentially does by eliminating those which conform less readily to the requirements of the environment, can hardly be dismissed, as M. Constantin dismisses it, as of relatively small importance in the evolution of species. But the difficulty really does exist if we only assume the possibility of slight variation ranged equally round a mean. In this case, of course, it is difficult (apart from isolation, physical or physiological) to see how a new species could be evolved at all when the chances of intercrossing are considered. But, as has been indicated, such a restriction is entirely gratuitous, and, furthermore, is contradicted by experience.

The facts adduced by the author, drawn from the studies of Schübeler and Bonnier, on the sudden evolution of spring- from autumn-wheat, hardly seem to help the case of the inheritable influence of the surroundings at all. For it is conceded that if autumn-wheat be sown in spring, a large percentage of the plants do not ripen fruit. Those that do succeed may, however, be supposed so to develop because their latent possibilities in this direction were greater than those possessed by their unsuccessful comrades. Next year, of course, the sowings obtained from the survivors will possess the same character for speedy growth and early maturity in a far larger average number, since the parents *all* had clearly a trend in the required direction. But it is misleading to speak of this as an inherited effect due to the impressed action of the environment, *i.e.* the inheritance of an acquired character, for it is clearly nothing more than the encouragement of possibilities which were latent before, and, but for the changed conditions, might never have been raised to the position of criteria of existence at all.

But this confusion between an outside moulding influence (*e.g.* mutilation) and the *evoking* from the plastic organism of a suitable response to the environment imposed by new conditions, is very wide-spread; and although the difference is in reality one altogether of kind, it is often in practice overlooked.

A good summary is given of some of the interesting results obtained by French investigators on crossing races and species, but some of the other chapters strike one as rather weak, *e.g.* those dealing with the action of gravity on plants. The account of aquatic plants is also somewhat disappointing, especially as the author has himself worked in this branch of the subject.

Nevertheless, the book is worth reading, bringing together as it does a considerable body of scattered facts which are lucidly arranged within a moderate number of pages.

J. B. F.

## THE NEWTONIAN POTENTIAL.

*Théorie du Potentiel Newtonien.* By H. Poincaré. Pp. 366. (Paris: Georges Carré and C. Naud, 1899.)

THE course of lectures given by Prof. Poincaré at the Sorbonne during the session of 1894–5 has, under the editorship of Dr. Édouard Leroy and M. Georges Vincent, assumed the form of a text-book on attractions and the theory of the potential.

The subject-matter naturally falls into two sections, one referring to special properties of potentials of linear, superficial and volume distributions, and the other dealing with Dirichlet's problem and its solution. It is rather a pity that this division was not adhered to in the arrangement of the text. Chapter vi., dealing with the potentials of magnetic shells, is quite out of place in the middle of Dirichlet's problem, and should logically have preceded the two previous chapters.

In opening what we have regarded as the first subject, M. Poincaré introduces concurrently with the Newtonian potential the logarithmic potential corresponding to the law of the inverse distance, which represents the two-dimensional potential of infinite cylindric distributions. The first chapter, which includes calculations of the potentials of rods, cylinders, spheres, and other simple forms, deals with potentials of bodies at external points. It contains a brief account of Legendre's coefficients. In passing to the interior of the attracting mass in Chapter ii., the question of the convergency of the integrals representing the potential and its derivatives naturally necessitates a brief digression on convergent integrals in general. Chapter iii. deals with potentials of linear and superficial distributions of matter, and naturally leads on to the misplaced Chapter vi., which treats at considerable length of "double layers" (*doubles couches*)—in other words, magnetic shells.

The second subject opens in Chapter v., where Dirichlet's problem is stated, the principal properties of Green's function are proved, and the equivalence of the two problems is established. In the next chapter Prof. Poincaré gives the solutions of Dirichlet's problem for a circle and a sphere, and deals with the properties of conjugate functions and conformal representation in two dimensions. Chapter vii. treats of the method of exhaustion (*balayage*), and the remaining eighty pages contain a fairly detailed account of Neumann's method and its extensions.

Lecture notes are rather apt to be deficient in explanation on points which have either been taken for granted by those who transcribed them, or have been incidentally explained in a conversational way by the lecturer. Any one not starting with a previous knowledge of the definition of the potential would hardly find M. Poincaré's opening very clear. In first "letting" $f_1'(r_1)$ be the attraction at distance $r_1$ and afterwards defining the potential as $-\Sigma f(r)$ it ought to be explicitly stated that $f_1'(r_1)$ is the derived function of the subsequently introduced function $f_1(r_1)$. Moreover, why should the constant of integration in $f_1(r_1)$ be taken as zero in the Newtonian and as $-m \log r_0$ in the logarithmic potential? A few additional words of explanation in such cases would often save readers from wasting time over unnecessary difficulties.

There are many problems which, although belonging to the subject proper of attractions and potential, are not included in the present volume. The potentials of ellipsoids are untouched, Lamé's ellipsoidal harmonics being dismissed with a mere reference. Then, again more might have been said about spherical harmonics. It will be seen, however, that M. Poincaré's lectures have reference to the general theory of the potential rather than to special problems, which find appropriate treatment elsewhere.

As an introduction to this theory dealing at some length with Dirichlet's and Neumann's developments, M. Poincaré's volume bids fair to be a useful addition to the library of college lecturers as well as of the more advanced class of mathematical students.

G. H. B.

## OUR BOOK SHELF.

*Faune de France—Mammifères.* By A. Aclogue. Pp. 84; Figs. 9. (Paris: Baillière.)

As compared with that of the British Isles, the mammalian fauna of France is much more extensive, comprising a number of Mediterranean types quite unknown among the former. It is therefore, altogether apart from patriotic considerations, well worthy of being separately monographed. This task has been undertaken by the author of the present little volume; and although in the main the very condensed descriptions given appear satisfactory so far as they go, we cannot but regret that the work was not written more on the lines of Bell's "British Quadrupeds."

The volume commences with an illustrated dissertation on the characteristics of, first, the Vertebrata and then of mammals; and in this part we notice that on p. 21 the author figures the skull of a bat as that of a mole, and also one of a porcupine as that of a second representative of the insectivorous order.

The illustrations are, indeed, very discreditable, the only passable ones being those borrowed from other works. In these days of cheap "process-blocks" it does seem inexcusable to issue caricatures like those in the present volume. The type, too, is extremely small.

The descriptions of the genera and species, although, as already said, very short, are sufficient to admit of their identification. Some of the terms used, such as (p. 73) "*Bosidi*"—the equivalent of *Bovidae*—sound, however, somewhat strange to English ears; and it may be added that the nomenclature generally is by no means altogether up to date. Moreover, even if it be considered advisable in a work of this nature to introduce the ordinary indigenous domesticated animals, such as sheep and oxen, there seems little to justify the inclusion of such a palpable foreigner as the guinea-pig.

The best we can say is to express the hope that the author may, before long, see his way to reissue what forms the rudiments of a very useful work on a scale more commensurate with the importance and interest of the subject.

R. L.

*Anatomical Diagrams for the use of Art Students.* By James M. Dunlop. Pp. 72. (London: George Bell and Sons, 1899.)

As to how much or how little knowledge of anatomy the art student should possess is a matter on which opinion is very much divided. Your youthful impressionist is apt to sneer at anatomy; as a rule, his contempt for the subject is revealed in the construction of the forms he represents. On the other hand, the more serious-minded and studious of the artistic fraternity, those who, by hard work and diligent study, are laying the foundations upon

which a true impressionism can alone be based, have found and do find the study of anatomy a help in their work.

That such knowledge may be abused is not surprising; the example of the unfortunate Haydon might serve as a warning. Yet there are plenty of instances in modern work in which this knowledge is duly restrained. Leighton had a keen appreciation of anatomical detail, and his bronze of an Athlete struggling with a python is likely to outlive most, if not all, his pictorial efforts as a work of art.

Books on so-called artistic anatomy, written usually by surgeons and anatomists having little or no knowledge of the requirements of artists, have, as a rule, been prepared by "boiling down" the technical treatises supplied to medical students. It is to Dr. Paul Richer that we are indebted for having dealt with the subject in an appreciative spirit; he approaches it, not merely from the standpoint of the anatomist, but from that of the artist as well. His method is to represent the figure in action in different poses, and submit a chart explanatory of the various structures on which the surface contours depend, having first, of course, supplied his readers with such information regarding the bones and muscles as is necessary to enable them to understand and appreciate the diagrams. It would be difficult to over-estimate the value of his book; its cost, however, places it beyond the reach of most students.

When an art-master produces an atlas of anatomical diagrams, we naturally expect to have fresh light thrown on the subject, together with a keener appreciation of the requirements of art students. We are not inclined to be too exacting with regard to the anatomical details if only we can get some further insight into their application to the study of the human figure.

In an interesting introduction to the present volume, Prof. Cleland, whose artistic sympathies are well known, makes use of the statement that the work occupies "ground which has not hitherto been taken up." With this opinion we cannot agree; for, as a matter of fact, the bulk of the illustrations in this atlas are reproductions, somewhat diagrammatically treated, of tracings or combined tracings of Richer's drawings. To these the author has had no hesitation in affixing his name without, so far as we can ascertain, once mentioning the source from which his figures are derived. The only features in the book which display any originality are the plates in which those parts of the skeleton having a direct relation to the surface contours are blocked in in distinctive colours. The absence of explanatory text, as well as the lack of reference to the contours of the figure in action, seem to us to minimise its value as a textbook to be placed in the hands of students. As diagrammatic reproductions of Richer's figures, the plates in this atlas may not be without value. We confess, however, to a preference for the originals.

*Chemistry for Continuation Schools.* By R. L. Taylor. Pp. 52. (Manchester: Thomas Wyatt, 1899.)

THIS little book, like many others which have appeared during the past few years, should assist the progress of rational methods of teaching elementary chemistry. It consists of a series of nearly a hundred simple experiments to be performed by or for pupils commencing the study of chemistry. The subjects illustrated by the experiments are elements and compounds, chemistry of the air, water, acids and alkalis, carbon and carbon dioxide. Pupils who perform the experiments will obtain a sound knowledge of the nature of chemical changes, and of the properties of some common substances.

Fig. 3, illustrating the preparation and collection of oxygen from potassium chlorate and manganese dioxide, shows a liquid in the flask instead of the oxygen mixture.

## LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### Blue Ray[1] of Sunrise over Mont Blanc.

LOOKING out at 5 o'clock this morning from a balcony of this hotel, 1545 metres above sea-level, and about 68 kilometres W. 18° S. from Mont Blanc, I had a magnificent view of Alpine ranges of Switzerland, Savoy, and Dauphiné; perfectly clear and sharp on the morning twilight sky. This promised me an opportunity for which I had been waiting five or six years; to see the earliest instantaneous light through very clear air, and find whether it was perceptibly blue. I therefore resolved to watch an hour till sunrise, and was amply rewarded by all the splendours I saw. Having only vague knowledge of the orientation of the hotel, I could not at first judge whereabouts the sun would rise; but in the course of half an hour rosy tints on each side of the place of strongest twilight showed me that it would be visible from the balcony; and I was helped to this conclusion by Haidinger's brushes when the illumination of the air at greater altitudes by a brilliant half-moon nearly overhead, was overpowered by sunlight streaming upwards from beyond the mountains. A little later, beams of sunlight and shadows of distant mountains converged clearly to a point deep under the very summit of Mont Blanc. In the course of five or ten minutes I was able to watch the point of convergence travelling obliquely upwards till in an instant I saw a blue light against the sky on the southern profile of Mont Blanc; which, in less than the one-twentieth of a second became dazzlingly white, like a brilliant electric arc-light. I had no dark glass at hand, so I could not any longer watch the rising sun.

KELVIN.

Hotel du Mont-Revard, above Aix-les-Bains,
August 27.

### A Fold Making Apparatus for Lecture Purposes.

I HAVE found the piece of apparatus which I am about to describe so effective for lecture experiments, that I venture to think that others engaged in geological teaching may be glad to possess details as to its construction and mode of operation.

The machine (Fig. 1) consists of two parallel wooden rollers, about 3 feet apart. Each is about 12 inches long and 4 inches

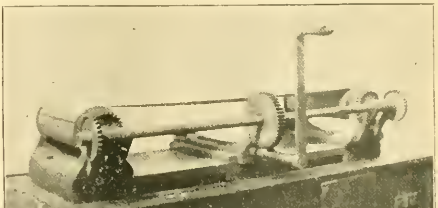


FIG. 1.

in diameter. A shaft at right angles to their length turns the two rollers in opposite directions by means of toothed bevel wheels, the shaft itself being driven by a worm wheel and worm, the latter being actuated directly by the handle. One turn of the handle only causes $\frac{1}{4^0}$ turn of the shaft and rollers, so that a very slow motion can be imparted to the latter. A sheet of

[1] The "Rayon Vert" of Jules Verne is the corresponding phenomenon at sunset; which I first saw about six years ago.

india-rubber about $\frac{1}{2}$-inch thick, firmly attached by a slot and screwed bar to each roller, completes the arrangement.

The rollers being wound through about one entire revolution, and the india-rubber being thus stretched tight, layers of cloth, clay, paste or other giving material, are laid upon it. The handle is then turned in the reverse direction, and the india-rubber gradually released. Folds are in this way shown slowly growing—the broad elastic band simulating the contraction of a portion of the earth's crust. In Figs. 2 and 3, cloths are seen

FIG. 2.

FIG 3.

folded thus—first, without superincumbent weight, and second, with a weight of 30 lbs.

That the larger folds are those generated at the surface, and the smaller and more numerous those produced under pressure (*i.e.* at great depths), is here made evident.

By substituting blocks of stone or wood for ordinary weights above the cloths (Fig. 4) and repeating the experiment, some of the relations between folding and faulting are clearly shown.

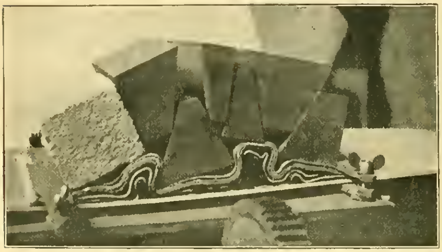


FIG. 4.

If clay be used instead of cloths, all the results of Favre's well-known experiments (*Arch. d. Sciences Phys. et Nat.*, 1878, and also NATURE), and many of those described by Cadell, Bailey Willis and others, can be obtained, and with the exercise of a little ingenuity it is easy to vary the experiments so as to reproduce a large number of the fold-forms known, and to illustrate their consequences—thrusts, faults, &c.

This machine was made for me in 1880 by the late Mr. C. D. Austen, of Newcastle-upon-Tyne, from my designs.

G. A. LEBOUR.

The Durham College of Science, Newcastle-upon-Tyne, August 18.

## Scoring at Rifle Matches.

IN his letter to NATURE of August 17, Mr. Mallock appears to assume that there is such a thing as abstract "accuracy" in estimating the value of a marksman's score. The method in use at Bisley is, as I understand him, to be regarded as a rough approximation to the accurate method, whether the best available approximation or not. Is it not rather the case that the standard of accuracy is itself arbitrary, and what the authorities at Bisley have established is not an approximation to an ideal standard, but is to be regarded as a real standard of excellence?

In result Mr. Mallock's "accurate" method is this: in his notation any two scores for which $R^2+\rho^2$ is the same are of equal merit, or that one for which $R^2+\rho^2$ has the least value is the best score. Now, if "$a$" be the distance of any shot mark from the bull's-eye, $n$ the number of shots, $R^2+\rho^2=\Sigma a^2/n$. Mr. Mallock's standard, then, is that the best score is that for which the sum of the squares of the distances from the bull's-eye is minimum. I see no reason why this method should be regarded as accurate *par excellence*, except the analogy of the method of least squares. But the analogy is misleading.

Where the method of least squares is applicable, the object is to find the most advantageous value of an unknown quantity to be deduced from a number of observations. An accurate value of the quantity does exist. And of two or more results deduced from the observations, that which is nearer to the accurate value is always better than one more remote, however near to the truth either may be.

In rifle shooting, on the other hand, there is generally some finite space—*e.g.* the port-hole of an enemy's ironclad, such that all shots which pass through it are of practically equal value, and all shots which do not pass through it are of little or no value.

This is much more accurately represented by the Bisley method than by the method which Mr. Mallock would substitute for it.

S. H. BURBURY.

THE only remark I should wish to make on Mr. Burbury's letter is that every shot on the target is truly the record of an observation, and that there is every reason to treat these records as far as is practicable by the methods which apply in obtaining the best means of a number of observations. Of course, it is only in the case of "centre of target" competitions the "$R^2+\rho^2$ a minimum" test applies. Prizes might well be given for close grouping, with a penalty depending on the mean distance of the group from the centre of the target.

August 22. A. MALLOCK.

## Spectrum Series.

SIR NORMAN LOCKYER'S lectures on "Spectrum Series" seem to show very clearly the important fact that there is a close connection between the valency of an element and the lines in its spectrum.

The connection indicated is as follows:—

Nonvalent elements yield spectra with single lines.

Monovalents yield doubles.

Divalents yield triplets.

On turning to the list given in NATURE (vol. lx. p. 370), it will be seen that helium, by yielding doubles as well as singles, and cobalt, by yielding doubles only, are practically the only discordant cases in Sir Norman Lockyer's list, since aluminium and indium are trivalents, and their anomalous behaviour in yielding doubles only can perhaps be explained.

August 26. W. SEDGWICK.

## Magnetic "Lines of Force."

IN some text-books and by some lecturers (*e.g.* Prof. A. Gray, as reported in NATURE of August 17, p. 379), the lines of magnetic force are said to be the curves along which iron filings are marshalled when sifted over a piece of card laid over a horizontally placed magnet.

Surely this is hardly correct. The true lines of magnetic force must be represented, like those of all other radiant forces, by radiating straight lines drawn through the points of action of the resultants of all the forces residing in the individual molecules of a given magnet (such points, though varying in position with the position of a magnetic body in the field, being often referred to as fixed "poles").

The symmetrical figures traced out by iron filings merely show, of course, the directions in which a line joining the poles of a very short magnet will lie in different parts of a magnetic field, under the influence of the true lines of force. E. R. P.

August 29.

## Critical Pressure.—A Suggested New Definition.

THE critical pressure of a substance is commonly defined as "the least pressure that will suffice to reduce that substance from the gaseous to the liquid state when at its critical temperature." But this definition contemplates the matter solely from the standpoint of what occurs at the critical temperature, and I think it

would sometimes be an advantage to have one presenting a broader view and making no reference to any specific temperature, just as the ordinary definition of critical temperature makes no reference to any specific pressure.

Now, if in a *pv* diagram we draw the curve formed by the liquid and vapour lines, the indicator points corresponding to the "mixed state" (*i.e.* part vapour and part liquid, each more or less distinctly discernible) lie wholly within the region bounded by this curve and the axis of volume; also the ordinate of the highest point of this curve—where, of course, the tangent is horizontal—corresponds to the critical pressure, and the "critopiestic" or critical pressure line is the said horizontal tangent.

All horizontal lines below the critopiestic intersect the region corresponding to the "mixed state," while those above do not, thus showing that at pressures below the critical the substance changes from gas to liquid, or *vice-versa*, by the *ordinary* process of condensation or evaporation, *i.e.* by passage through the mixed state, while above that pressure this process does not take place, but the change occurs by continuous and imperceptible transition.

Of course all this accords with experiment, as is pointed out in several, though by no means all, the standard text-books. Thus on p. 123 of the new edition of Clerk Maxwell's "Theory of Heat," revised by Lord Rayleigh, we read:—"If we begin with carbonic acid gas at 50° F. we may first heat it till its temperature is above the critical, 88° F. We then gradually increase the pressure to, say, 100 atmospheres. During this process no sign of liquefaction occurs. *Finally we cool the substance still under a pressure of* 100 *atmospheres to* 50° *F. During this process no sudden change of state can be observed, but carbonic acid at* 50° *F. and under a pressure of* 100 *atmospheres has all the properties of a liquid . . . by this process we have caused the substance to pass from an undoubtedly gaseous to an undoubtedly liquid state without at any time undergoing an abrupt change similar to ordinary liquefaction.*"

Again, on p. 206 of the "Text-Book of Physics," by Mr. Alfred Daniell, we find:—"If $CO_2$ gas be exposed to a temperature above 30°·92 C. and be subjected to any pressure above 73 atmospheres, it will still be a gas: *allow it to cool, the pressure being kept up, and it will be a liquid after it passes* 30°·92 *C., and yet the transition is unobservable.*"

I therefore propose to define the critical pressure of a substance as "that pressure above which it is impossible to make the substance undergo the *ordinary* process of condensation (or evaporation)"—or if greater amplification is needed as "that pressure above which an appropriate alteration of temperature causes the substance to pass from the gaseous to the liquid state or *vice-versa, by a process of continuous and imperceptible transition*, and not, as happens below that pressure, by *passage through the mixed state.*"

This definition I have given in my recently published book, "Physics: Experimental and Theoretical," but the *Times* reviewer, in a paragraph in that paper of July 29, characterises it as "mere nonsense."

I shall be greatly obliged if you will publish this letter, together with your opinion on the validity of my definition. Perhaps also some of your readers may favour me with an expression of their views. R. H. JUDE.

Newcastle-upon-Tyne, August 2.

### Maternal Devotion of Spiders.

ON removing some virgin cork from the wall of a conservatory a short time ago, I was much struck with the way in which a small black female spider clung to her two egg-bags, despite the fact that the piece of cork to which she was clinging had been thrown roughly to the ground. When the cork was about to be replaced on the wall, it became necessary to turn the spider adrift, in order to prevent her being crushed. But although the cork was shaken, she declined to budge, and retained a tight hold upon her precious bags. Knowing how fully alive to danger the spider race is in general, I thought that this remarkable instance of devotion to maternal promptings on the part of a naturally sensitive creature ought not to be disregarded. I accordingly removed the mother very carefully, and placed her on some rockwork, where I noticed she seemed to be very uneasy, moving restlessly about as if searching for something. I then took the egg-bags and placed them beside her. As I expected, she seemingly failed to recognise them, or at least manifested a repugnance to them, and ran away for a little distance. Subsequently, however, she returned, and proceeded to examine the bags with scrupulous care by means of her palpi; and evidently satisfied with this scrutiny that they were really her own cherished property, she commenced to spin a web about them to secure them in their place.

Rennie has described experiments with the females of certain spiders which carry about their egg-bags attached to their bodies. When one of these spiders was molested, and its bag dragged with a stick, the mother seemed to lose all sense of personal danger in her anxiety for her unhatched offspring, and fought vigorously to retain her precious egg-bag. When forcibly deprived of the bag, she manifested great distress, and commenced a search for it, and, not finding it, she refused to leave the spot, seeming to be quite indifferent as to her fate. The curious part of the story is that when the egg-bag was finally restored to her, she refused to touch it, being apparently quite unable to recognise her property. In another case the spider regained possession of the bag as it was being withdrawn, and immediately refixed it in its former position.

My spider apparently recognised her egg-bags without much difficulty, and, furthermore, seemed to be alive to the danger to which they were exposed in their new situation by her act of spinning a protecting web without delay. When evening arrived, I observed that she had drawn the bags close up under a sheltering leaf, and was guarding them closely, having placed herself between them. FRANCIS J. ROWBOTHAM.

August 23.

## THE CAMBRIDGE ANTHROPOLOGICAL EXPEDITION TO TORRES STRAITS AND SARAWAK.

THE main object of the expedition was to verify and supplement the anthropological observations that I made in Torres Straits in 1888–89, with the view of the publication of a monograph dealing with the anthropology of the islanders using that term in its widest sense. A few months before leaving I received such a pressing and enthusiastic invitation from Mr. Charles Hose for the expedition to visit the Baram district of Sarawak, that I felt constrained to extend the scope of our work by accepting his tempting offer. The party consisted of Dr. W. H. R. Rivers, Messrs. C. S. Myers, W. McDougall, S. H. Ray, A. Wilkin, C. G. Seligmann, and myself.

The Torres Straits islanders are Papuans, and as they inhabit the remains of the old land communication between Australia and New Guinea it was important that they should be thoroughly studied before it was too late. The islanders have been more or less under mission instruction since 1872, and some time before then the pearl-shelling industry had commenced. Owing to the varied influences of the white man, modification was bound to take place rapidly, and unfortunately in most islands more or less extensive depopulation has also occurred. There are two distinct tribes in the archipelago—the eastern tribe inhabits the Murray Islands, Erub (Darnley Island) and Uga, and the western tribe the remaining islands. The latter people have been most under the influence of white men, scarcely a pure-blooded native exists in Erub, but the Murray Islands, on account of their remoteness and the difficulties in reaching them owing to numerous coral reefs, have been less visited. As Mer, the chief island of this group is very fertile, and has a population of some 450 people, it appeared to be the best centre for our work.

We reached Mer on May 6, 1898, and took possession of the disused mission residence, which we speedily converted into anthropological, psychological and photographic laboratories. Here we measured 63 men, 5 women, 30 boys, and 22 girls. The average height of the men is 1·653 m. (5 ft. 5 in.); their cephalic index is 77·5. Although reference is made here only to the cephalic index and the height, I may state that we usually made

twenty-two measurements on the subjects in Torres Straits, New Guinea, and Borneo, besides a number of observations on the skin, hair, eyes, face, &c.

Psychological observations were made in the Murray Islands on about 150 individuals. Among the subjects investigated were visual acuity, delicacy of colour sense, colour blindness, binocular vision and visual perception of space; acuity and range of hearing, appreciation of musical intervals; tactile acuity and sensibility to pain, and discrimination of weight; acuity of smell; simple reaction time to auditory and visual stimuli and choice reaction time; estimation of intervals of time; the influence of various mental states on blood pressure; and the influence of fatigue and practice on the capacity for mental work. By means of colour matches, quantitative records were also taken of the colour of the skin of the islanders.

We were fortunate to find two or three old men who were able to tell us about the old customs and ceremonies. A good deal of time was spent in elucidating the long since abandoned sacred Malu ceremonies which were held in connection with the initiation of the youths; the previous account[1] can now be considerably augmented. Notes were made of various other ceremonies, and whenever possible the ancient sacred songs were recorded on the phonograph. A large collection was made of sacred stones, including stones about which there is a legend, sorcery stones, fishing and garden charms, rain and fire charms. Numerous legends were also collected, and many of the sites and stones connected with them were photographed by Mr. Wilkin.

The old oracle known as "*Tomog zogo*," which consisted of a group of large shells on stones, to represent each group of houses on the island, and a shell "house" for the *zogo*, was plotted, and the former method of divination was demonstrated to us. One or two members of the party learnt the constellations on the voyage out; this enabled us to map some of the native star groups. Attention was also paid to children's games, and a system of nomenclature was devised which enabled us to record with accuracy the complicated manipulation in the making of the ingenious string puzzles or "cat's-cradle." Examples of the past and present handicrafts of the people were collected. The construction of the language was carefully studied by Mr. Ray, and the previously published vocabulary increased. The native diseases and their cures were studied with the cognate charms and magic.

Messrs. Ray, Seligmann, Wilkin and myself paid a brief visit to the mainland of New Guinea, and visits were paid to Rabao (Yule Island) and to several villages of the Mekeo district. Twenty-eight men were measured: average height, 1·610 m. (5 ft. 3½ in.); cephalic index, 80. As the decorative art of the Mekeo district has not been described hitherto, numerous specimens of lime-gourds, tobacco-pipes, and painted tapa were collected.

A short stay was made at Port Moresby, where a number of photographs were taken to illustrate the manufacture of pottery, and a visit was paid to the Taburi tribe that lives behind Mount Warirata. Nine mountaineers from the centre of the Peninsula were measured: height, 1·607 m. (5 ft. 3¼ in.); cephalic index, 80·8, as well as fourteen Koiari from the hilly country: height, 1·600 m. (5 ft. 3 in.); cephalic index, 75·5; and six Koitapu of Port Moresby: height, 1·603 m. (5 ft. 3 in.); cephalic index, 77·1. A study of the Koitapu language was made, which proved that it, like the people themselves, does not belong to the Motu stock. These three groups differ in several respects from the Motu communities that inhabit most of the coast villages from Delena to Aroma; for example, they commonly wear hair on the face, and the hair is almost invariably frizzly.

A few days were spent at Bulaa (Hula), where we were struck by the relative prevalence of curly and even of wavy hair, and the general lighter colour of the skin: height, 1·663 m. (5 ft. 5½ in.); cephalic index, 82·5. I intend on a future occasion to discuss the physical characters of the Papuans at some length when I have had time to tabulate out our results, and to compare them with those of other workers. At present it appears to me that a short, slightly brachycephalic people live among the mountains, and a similar short mesaticephalic (with a distinct tendency towards dolichocephalism) folk live nearer the coast. It is the latter people who have been repressed by the taller brachycephals of the coast, whose foreign blood is shown by their lighter skin and a marked frequency of curly or even wavy hair. The mountaineers are in no sense a pygmy people, and are not directly related to the Aëtas; they frequently harass and conquer the dolichocephals.

Messrs. Ray, Wilkin and myself returned to Murray Island on July 20, Mr. Seligmann remaining behind to see more of the country. Dr. Rivers and Messrs. Myers and McDougall had made a large number of interesting psychological observations during our absence. The two latter left for Borneo on August 24.

On September 8 we left Murray Island and arrived at Saguane at the southern end of Kiwai Island in the delta of the Fly River on the 11th. A visit was paid to Iasa, which contains sixteen long houses, each of which is inhabited by members of one totemistic clan, and eleven natives were measured: height, 1·602 m. (5 ft. 3 in); cephalic index, 80·3. Mr. Seligmann rejoined us here.

Our next destination was Mabuiag, which we reached on September 17, and had five weeks of good work recording old customs, measuring natives, studying language and experimental psychology. In Mabuiag and Kiwai fewer psychological observations could be made, owing to the fact that most of the apparatus had to be taken on to Borneo, but observations on visual acuity, colour vision, &c., were made on over 100 individuals, many of whom, however, were not natives of these islands. Thirty-three men were measured: height, 1·648 m. (5 ft. 4¾ in.); the average cephalic index is 81·1. Although they belong to the same race, and are similar in many respects, there is a noticeable difference between the eastern and western tribe of Torres Straits. Most of their former ceremonies and many of their customs were dissimilar, the languages are quite distinct, and on the whole the western folk are more intelligent. The very slight difference in the stature may be due to the more abundant food of Murray Island, whereas that of the head form is of greater significance. The difference between an average index of 77 and 81 may not appear large, but there is a distinct difference in the form of the skulls in general from the two islands. I am inclined to believe that the Murray Islanders belong to that dolichocephalic stock which certainly occurs on the mainland of New Guinea in the region known under the general name of Daudai, and which appears to have been pushed back by a somewhat brachycephalic people. Murray Island was unaffected by this movement, but the western islands have not escaped it. I have no desire to push craniological facts too far, and I propose testing this hypothesis elsewhere by cultural evidence. Several writers have expressed an opinion that the natives of Prince of Wales Island and the neighbouring islands are Australians with a strong Papuan mixture. I regard them as Papuans, with a very slight (if any) Australian mixture.

The most interesting of our sociological investigations of the Western tribe were those on totemism, maturity customs for men and women, and the beginnings of hero-worship as exemplified in the legend and cult of Kwoiam, the national hero of Mabuiag. Here, as at Mer, Dr.

[1] *Internationales Archiv für Ethnographie* (vi., 1893, p. 140).

Rivers traced as far as possible the genealogy and relationships of every person on the island. This somewhat laborious work has proved a most valuable method of anthropological research, which, so far as I am aware, has not been attempted before for a whole community. The value of this method consists in the large number of accurate sociological data that are accumulated.

Short visits were paid to other of the western islands of the Straits in which ethnographical facts and specimens were collected.

At Mabuiag, and later at Thursday Island, we had an opportunity of studying some North Queensland natives, and the contrast, both mentally and physically, between them and the islanders was obvious. The average height of seventeen Queenslanders was 1·626 m. (5 ft. 4 in.), and their average cephalic index was 74·5.

We finally left Torres Straits on November 15, 1898.

Messrs. Ray, Seligmann and myself reached Kuching on December 12, where we had to remain until January 4; Mr. Ray occupied the time in learning Malay, and I laid the foundations of a study of the decorative art of Sarawak by utilising the collections in the most excellent museum which the Rajah has so wisely and liberally endowed. The foundation of the ethnographical collections was the very valuable Brooke Low collection, which the Rajah bought in England and reshipped to its native land. This has been added to from time to time, and, although there is a good deal to be done before all the handicrafts and arts of the natives of Sarawak are fully illustrated, the museum contains the best and most instructive collection of Sarawak ethnography extant. The fauna of Sarawak is also most fully represented, and the value of the collections is daily increased by the well-directed labours of the curator, Mr. R. Shelford.

During the north-east monsoon it is impossible for a steamer to cross the bar at Baram Mouth, and this necessitated our proceeding to Limbang, where we had to remain a few days whilst messengers were sent to Mr. Hose. We then had to journey some 200 miles in boats up the Limbang, Madalam and Trikan rivers, and after walking across the watershed at the foot of Mount Mulu we descended the Malinau, Tutau and Baram, arriving at Marudi (Claudetown) on January 28, where we rejoined Mr. McDougall, Mr. Myers having been obliged to return home a few days previously. On February 6 Mr. Hose took Messrs. Ray, MacDougall and myself an up-river trip, Mr. Seligmann was busy studying *upoh* (*upas*), *tuba* and other poisons; later he stayed some time among the up river Kayans. We went over 200 miles up the rivers Baram, Tinjar, Dapoi and Lobong, and saw many interesting scenes, and gained further experience of the jungle vegetation of a typical tropical land.

At Long Puah we witnessed the ceremony of moving the skulls into a new house from the hut in which they had been temporarily lodged, and then we participated in the ceremony of naming the first-born son of the chief. On the same occasion peace was made between two hostile tribes, and the covenant was ratified in the usual manner by "speaking" to some pigs, that were then killed and their livers inspected for augury. In one village we saw a Punan medicine man exorcise fever from a white man by means of incantations and obvious thaumaturgics. We gained fair insight into the mode of life and beliefs of several tribes of the interior; we made collections to illustrate their handicrafts and decorative art: numerous photographs were taken, which unfortunately have not proved a success owing partly to climatic conditions. Physical measurements were made of a large number of natives, and vocabularies collected. We also had an excellent object-lesson in the paternal administration of native affairs that is the keynote of the Sarawak system of government.

It was on this trip that I discovered a stone implement in a native house, close by the usual skulls and associated with other sacred objects. After great difficulty Mr. Hose succeeded in procuring it, and later he secured several other specimens of varied types. With the exception of a specimen in the museum at Oxford of a very different type from any we obtained, and one recently acquired by the Sarawak Museum, these are the only authentic stone implements known from Borneo. Mr. McDougall and I paid a hurried visit to Mount Dulit, but nothing of interest was collected.

Later on Mr. Hose took me to visit Tama Bulan, the great Kenyah Penghulu, who lives on the Pata River. Messrs. Myers and McDougall had previously visited him.

Towards the end of our stay in Baram we were present at a great peace-making, when quite 6000 natives assembled from all parts of the Baram district, and even from beyond its borders. We thus had an unique opportunity of seeing representatives of nearly every important tribe of the Raj. Amongst other incidents we witnessed a canoe race in which about one thousand men competed, and participated in an attempt to *tuba*-poison a large lake in which over two thousand men were engaged.

We have now in Cambridge specimens to fairly well illustrate the arts and crafts of the natives of Sarawak. Mr. Ray obtained material for grammars of the two dialects spoken respectively by the Land Dayaks and by the Sea Dayaks, as well as notes upon several other languages. Vocabularies of over 200 words were obtained in forty-six dialects spoken by various tribes of Sarawak. Mr. Myers made numerous psychological observations. Mr. Seligmann studied native medicine, &c. Mr. McDougall paid special attention to the question of the relations of men to animals and plants in Borneo, and helped me with the measurements and physical observations of the natives. In all we measured some 276 natives, the bulk of whom are mesaticephalic or slightly brachycephalic. The following are some of the approximate average indices (the numbers in brackets refer to the number of each tribe that were measured):—Maloh (7)—probably an immigrant people from Java—76; Barawan (17), 77·5; Kalabit (10), 78; Kenyah (103), 79—of these the Sibops (5) have the lowest index with 75·5, which gradually rises through the Malangs (20), 76·5, Tabalos (3), 77·5, Madangs (6), 78, Long Pokun (19) and Lirong (15), 79·5, Long Dallo (12), 80·5, Apoh (9), 82, to the Long Sinong Kenyahs (5), with an index of 83·5—this does not appear to be a very homogeneous group; Kayan (22), 80; Long Kiput (9), 80·5; Punan (22), 81; Sea Dayaks (53), 83; Malanaus (7), 85·5; Brunei-Malay (1), 85·5. We have not yet had time to study the skulls we brought away. I had an opportunity, however, of measuring five Murut skulls at Limbang, which had an average index of 75· (extremes 73–77·5). It is thus evident that there is a dolichocephalic element in Borneo which may be identical with the Indonesians as defined by de Quatrefages and Hamy in "Crania Ethnica." There is also a low brachycephalic element found among the up-river Kenyahs (Long Sinong, Apoh, and Long Dallo), Punans, and to a less extent among the Kayans. The Sea Dayaks are not an indigenous population; they probably constituted the advance wave of a later Malay migration. The Malanaus are Mohammedans greatly influenced by Malays, and who very frequently artificially deform the heads of their babies, so their relatively high index of 85·5 may be neglected. Although the Punan cephalic index (81) is close to that of the Sea Dayaks (83), the slender pale-coloured forest-dweller is physically very different from the short, sturdy, dark-skinned, low-country agriculturist. We were fortunate in coming across several groups of Punans, a nomadic jungle folk who are certainly one of the most primitive people in Borneo, and who may, perhaps, be the true autocthones of the country, for there is no

authoritative evidence for the existence of Negritos in Borneo.

The fascinating promises of Mr. Hose when he sent me his invitation to visit him were amply fulfilled so far as time permitted, and we have to thank him for a most enjoyable and instructive visit. Mr. Charles Hose is well known as a highly successful and enthusiastic naturalist. He has made collections in all departments of the land fauna of Sarawak, and he has monographed the mammals and the birds. His geographical explorations are also well recognised; but it is not generally known that he has a most minute and extensive knowledge of all that pertains to the numerous and varied natives that have been entrusted to his sympathetic care. I have seen piles of immensely valuable ethnographical manuscript which we sincerely hope will be suitably and speedily published. Not only has Mr. Hose from time to time presented his old University with numerous zoological specimens, but he has entrusted to me an extensive and very valuable collection of ethnographic specimens which he has given to the University of Cambridge. In addition he has presented the unique collection of stone implements and a large collection of human crania, each skull being labelled with its tribe and provenance.

I shall endeavour on another occasion to do justice to Mr. Hose's success as an administrator. What we were able to accomplish was largely due to those personal qualities of a ruler which awaken a feeling of affection and loyalty in the natives.

The Cambridge University Press will publish the scientific results of the Expedition in due course as a series of memoirs which will be obtainable separately. The volume on experimental psychology will be written by Dr. Rivers and Messrs. Myers and McDougall, with some supplementary observations on the natives of the mainland of New Guinea by Mr. Seligmann. Mr. Ray has ample matter for a volume on linguistics.

The linguistic results of the Expedition were on the whole very satisfactory. Materials were obtained for complete grammars of the two Torres Straits languages, and the vocabularies were revised. In New Guinea the Melanesian languages around Hood Bay were studied, as well as those of Rabao (Yule Island) and the adjacent mainland. In New Guinea also material was obtained to elucidate the somewhat complex structure of the Papuan languages of the Koitapu in the Port Moresby district, of the Cloudy Bay peoples, and of the Kiwai and Mowatta tribes in the Fly Delta. No grammar of any of these languages has hitherto been written. The materials obtained in Borneo for grammars of the two dialects spoken by the Land Dayaks and Sea Dayaks, and vocabularies obtained in forty-six dialects spoken by various tribes of Sarawak have already been referred to.

The physical anthropology of Torres Straits and New Guinea will mainly be worked out by myself, but Mr. Seligmann has some additional measurements from the mainland of New Guinea. Dr. Rivers will publish and expound his statistical inquiries. Mr. Myers is making a comparative study of native music. Mr. Seligmann has studied native medicines and charms, and has made various ethnological observations of some interest. Mr. Wilkin has made notes on native houses in New Guinea. The religious ceremonies, legends, and general ethnology will be treated by various members of the Expedition. Mr. Wilkin took a large number of excellent photographs in Torres Straits and New Guinea, which will be drawn upon for illustrative purposes. As there is no room for them in the present Museum of Archæology and Ethnology, the extensive collections are deposited temporarily in a couple of small houses in Cambridge, where, unfortunately, they run risk of deterioration.

ALFRED C. HADDON.

## *WHY PEOPLE GO TO SPAS.*

ANY observer who has the curiosity to pass in review the modern methods of medical treatment cannot fail to be struck by the increasing amount of attention which is being paid at the present time, both by the laity and the profession, to the spa treatment of disease. The fact that many thousands of patients flock annually to the different health resorts to seek relief from their ills, and the idea which prevails among a large section of the educated public, chiefly the well-to-do classes, that their existence is not complete without a yearly visit to one or other of the many spas, either at home or abroad, and that for their bodily well-being an annual "cure" is necessary, are phenomena which call for comment and demand explanation. The practice is by no means of recent growth, for it finds its origin in the almost universal belief, prevalent in ancient times, in the efficacy of natural mineral waters and baths in the cure of disease. Many instances of this might be quoted. The waters of Spa in Belgium were celebrated in the time of Livy; the Romans built Bath in England, and fully recognised the value of its springs; and they in turn derived their fondness for bathing from the Greeks. There is not wanting evidence to show that more ancient civilisations appreciated in a rude way the benefits to be obtained in this direction from the resources of nature. Throughout the middle ages the same belief was held, and many were the pilgrimages to the various springs then known. In the present day the same idea, shorn of much of the superstition that formerly clung to it, still prevails, and each watering place claims annually its numerous devotees. Not only among the laity is the assurance of the therapeutic value of natural mineral waters and baths firmly rooted, though doubtless there still remains a substratum of lingering superstition as a part foundation of that assurance, but also by the medical fraternity their utility is accepted, as is witnessed by the freedom with which their patients are sent to take the waters of this or that spring. In the minds of the latter, however, superstition has been replaced by knowledge, and they are well assured that such treatment has a definite and real value.

It becomes, then, a matter of interest to seek answers to the following questions: Whether, in the light of modern knowledge and research there is a solid foundation in fact for the faith that is placed by patients and their doctors in the utility of bathing and water-drinking; whether such measures possess any advantages over treatment by ordinary medicinal means; whether the lines of treatment followed at spas cannot be carried out equally well at the patient's home, and the necessity for a perhaps inconvenient visit to a watering place thereby be obviated; and, lastly, whether equal facilities for such treatment, and results equally good, are not obtainable in this country as at similar places on the continent?

Up to comparatively recent times the use of waters and baths in the cure of disease was purely empirical. Through long experience and repeated trial it came gradually to be ascertained that certain waters were beneficial in certain cases, and certain kinds of baths produced certain effects; wherefrom was elaborated a system of spa treatment on more or less rule of thumb principles. The exact nature of the action of these agents, the physiological effects they produced and the pathological conditions they influenced were ill-understood; the rationale, in short, of the treatment was wanting. Of late years, however, a large amount of sound scientific work has been done in this department of medicine. The action of mineral waters and baths has been made the subject of definite experiment and the results obtained applied to the perfection and extension of the methods; and thereby this branch of therapeutics, which

formerly afforded tempting opportunities for scornful criticism on the part of the more advanced members of the profession, has now been placed on a firm scientific basis, and the ancient faith in it fully justified.

In this as in many kindred subjects the lead was taken by Germany, and as the result of much painstaking research a large amount of literature has appeared relating to the various spas in that country. Latterly the home watering places, such as Bath, Buxton, Droitwich, Harrogate, Leamington, Llandrindrod, Strathpeffer and others, have been brought more prominently before the notice of medical men, and through them to the public, by reason of similar research work conducted on scientific lines into the nature of the action of their respective waters and baths, by which their claims to equality with, if not superiority over, many of the continental resorts have been abundantly demonstrated. To illustrate this let us take Harrogate as an example, as possessing the greatest number and most varied assortment of mineral springs, and the most complete bathing establishment in this country, if not in Europe, and consider it with regard to its waters and baths. The former, some eighty in number, may be classified into certain groups of saline-sulphur waters, alkaline-sulphur waters, pure sulphur waters, saline-

F 1.—Entrance-hall and pump-room at the Royal Baths, Harrogate.

chalybeate waters, and pure chalybeates, each group embracing several members presenting fine gradations in quality and strength. The most important of these are set apart for drinking purposes; the others being collected, stored, and used for bathing. Long experience and trial of the waters has indicated the class of diseases in which they may be expected to prove beneficial, either individually or in combination, and these fall somewhat definitely into the following main groups, which, however, by no means include all cases which may derive benefit: disorders of the liver, functional or organic; cases of gout in its many manifestations; cases of rheumatism and so-called rheumatic gout; and cases of skin disease. The results obtained have been good, though based upon empirical knowledge, and a considerable reputation has been built up. In recent years, however, this has been strengthened by experimental work which has been carried out to determine the *modus operandi* of many of the waters, and the results of these researches have not merely corroborated in the main empirical practice, and furnished reasons for it, but have indicated new directions in which these agents may be advantageously employed. For example, the Old Sulphur Spring, the most valuable possession of Harrogate, has long been used in the past as a stimulant to the liver in sluggish or congested conditions of that organ. Recent research has shown by experiment on man and on animals that administration of this water definitely increases the flow of bile, as to rapidity, quantity, and the amount of solid constituents. And a further indication of increased activity of the liver is proved by an increase in

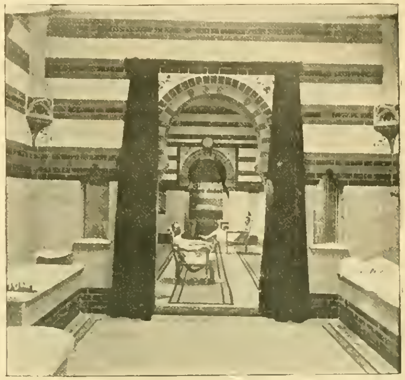


FIG. 2.—Interior of the Turkish Bath.

the amount of urea eliminated from the body. It has been used largely as a valuable remedy in gout, a part explanation of which is furnished by the diminished production of uric acid, which experiment shows to be one of the effects of this water. It has a well-marked effect on the blood in diluting it and diminishing slightly the amount of hæmoglobin, which explains its frequent use in plethoric conditions. The milder sulphur waters have

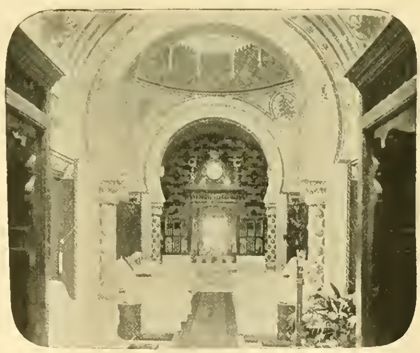
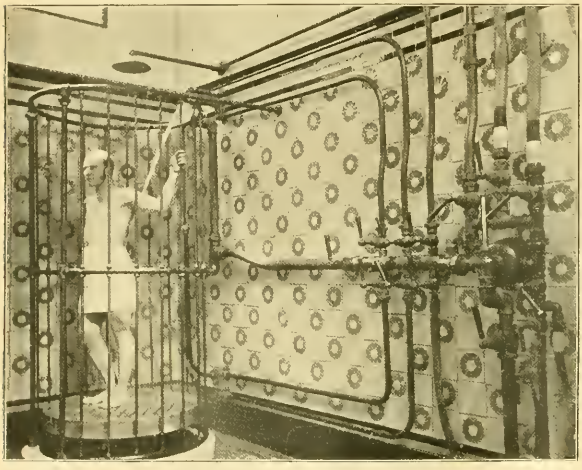


FIG. 3.—Cooling room of Turkish Bath.

been shown to have similar effects to a less extent. Further, the group of iron waters have been examined, and their effect on the blood in the building up of hæmoglobin repeatedly proved, and other unsuspected results on the general vital processes of the body been discovered, the Chloride of Iron water, for example, markedly increasing the elimination of urea, and diminishing that of uric acid; the "Kissingen" water

increasing the flow of bile without increasing the solid constituents; and so forth. Research of this description has been and is being carried on in the health resorts of this country, and though finality has by no means been reached, yet such endeavours to add to our knowledge should go far to enhance the reputation of each, to increase the confidence of patients who seek health there, and to remove any lingering prejudices that may still remain in the minds of scientific men as to the true worth of such treatment.

With regard to the baths, inquiry as to their mode of action has proved quite as satisfactory as in the case of the mineral waters. Through the forward policy adopted at Harrogate in providing a new and magnificent suite of baths including almost every variety, and replete with every modern convenience, it is possible there to undertake and carry out any line of balneo-therapeutic treatment that may be desired. The methods in use at the continental spas have been adopted and in some cases improved upon, any new development being at once installed and its utility or otherwise determined. The baths available, using the word bath in its widest sense,



*Greaves.*] [*Harrogate.*

FIG. 4.—The combined needle and douche bath.

may be classified into (*a*) *Thermal* baths, depending for their action mainly on the element of temperature, and including plain water baths, hot and cold, Turkish, Russian, superheated air baths, &c. (*b*) *Thermo-chemical* baths, in which there is added to the effects of temperature the effect of the chemical constituents of the water. They include the saline sulphur baths, alkaline-sulphur baths, saline baths, Nauheim baths, &c. (*c*) *Thermo-mechanical* baths, in which there is added to the effect of temperature the mechanical action of the water in the form of sprays, douches, effervescence, &c., with or without the mechanical effect of massage. These include the needle bath, combined needle and douche, running sitz bath, &c., and those with massage, the Aix douche and the Vichy douche. (*d*) *Thermo-electrical* baths, in which a current of electricity, either constant or interrupted, is passing through the water.

Each and all of these baths have their special effects, and abundant observations have been made to determine them experimentally as a guide to their intelligent use. The factors at work in the human organism that are disturbed in greater or less degree by even simple baths are so many, and their interaction so complex, that it becomes a matter of great difficulty, in the first place to measure them, and, in the second place, to estimate their relative importance; while in the case of the more complicated baths, where different elements, thermal, chemical or mechanical, are brought into play to disturb these factors, some in one direction and some in another, often apparently in direct opposition to each other, the difficulty becomes even greater. Thus, while we are able to ascertain approximately the net physiological result in any given case, it is impossible in the present state of our knowledge to do more than hazard conjectures as to the exact mode by which that result was produced—to what extent one factor was concerned and to what extent another. Still, in spite of the difficulty, collation of the results of various workers at home and abroad enables us to understand in some degree the rationale of bath treatment, and to place it on a sound physiological basis.

The influence of bathing in its various forms on the animal economy is profound, and no one who has not specially observed the effects produced can form an adequate idea of how potent that influence is. Broadly speaking, it may be said that the effects produced are the result of changes that take place in the circulatory system, which is the system mainly acted upon by the factors—thermal, chemical or mechanical—that may be at work.

The heart, driving the blood with its contained nutriment, derived from the alimentary canal, through a closed system of tubing, consisting of arteries, capillaries and veins, enables that fluid to penetrate to all parts of the body, there to deliver up its charge of food to the tissues by interchange of fluid through the thin capillary wall; receiving in exchange the waste products from the tissues, and bearing them away to be eliminated from the system. Variations in the amount of blood, and the force with which it is driven into the circulation at each heart beat, and variations in the calibre of the closed system of tubing will, with other factors, determine the tension of the circulation, or fluid pressure under which the blood is working—the blood pressure, as it is called. These variations are controlled by a nerve apparatus, the vaso-motor mechanism, whereby dilatation of vessels in one region of the body is compensated for by contraction in another, and the average level of blood pressure maintained, or changes produced therein. On the integrity of this nerve mechanism, and the perfect performance of its functions, the maintenance of health largely depends, for by it the ebb and flow of vessel constriction and dilatation is controlled, and the circulation enabled to adjust itself to the rapid succession of changes that take place in the environment of the organism—changes due to gravity, posture, exercise, digestion and the like. Further, on these changes in blood pressure depends to a large extent the ebb and flow of fluid through the capillary wall, whereby nourishment is conveyed to and waste products removed from the tissues; and, consequently, where this function is impaired the nutrition of the whole body suffers. By the recent introduction of new instruments it is possible to measure directly the blood pressure in the human subject, and to observe its

variations from hour to hour or day to day; and also to measure the varying calibre of the arteries in the extremities. We are thus able to form a fairly accurate estimate of the conditions of the circulation, and from these observations to infer the completeness or otherwise of the nutritional processes on which depend the well-being of the individual. In different morbid conditions the blood pressure may deviate considerably from the normal, the vaso-motor mechanism be impaired, and the free interchange of blood plasma and tissue fluid be defective, to the detriment of the organism. Experiment has shown that the blood pressure is markedly affected by baths, some procedures having the effect of raising it and some the reverse. The effect, though at first temporary, is cumulative, so that a permanent modification of pressure may be obtained, from which it follows that an intelligent use of bathing as a therapeutic agent can so act on the circulatory system as to regulate the blood pressure, restore the normal mobility of the vessels, promote the interchange of tissue fluid, and profoundly modify nutrition. By means of these new methods we can watch closely the changes occurring under treatment, and can adjust the latter to the requirements of any particular case with a delicate nicety.

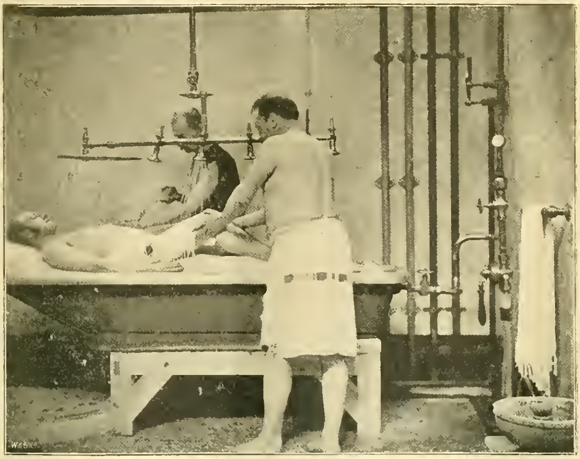
A few instances may be given of the effect of various baths on the blood pressure. Heat in all forms, whether dry as in the Turkish bath and superheated air baths, or moist as in the Russian bath, or the simple immersion bath, lowers the pressure. Cold, on the other hand, has the effect of raising it. The chemical constituents of the water in the case of the saline and sulphur baths also exert an influence, augmenting the fall in pressure resulting from warm baths. The percussion of water impinging sharply on the skin, as in the needle bath, tends to raise the blood pressure. Massage to the limbs and body causes a fall in pressure, provided the abdomen be not massaged too vigorously; deep pressure and manipulation of this part is followed by a marked rise in pressure owing to the dispersal of blood from the capacious veins of the viscera into the general circulation. In the Aix and Vichy douches massage is combined with warm douching.

In the former bath, massage is administered under a simple douche conveyed by a flexible pipe passing over the shoulder of the attendant and playing between his hands, the patient being in the sitting posture. The result on the blood pressure is to produce a fall, the massage and heat acting in the same direction. In the Vichy douche, however, the patient lies in the recumbent position, and is massaged under a needle spray falling from a bracket suspended over the table. Owing to the position adopted, massage of the abdomen is more freely performed, and this, combined with the tonic effect of the percussion of the needle spray, produces as a net result a rise in pressure.

The above considerations as to the mode by which tissue change is stimulated and nutrition modified by agents brought to bear on the circulatory system, serve to explain certain more remote effects experienced as the result of baths. To enter into these in detail is impossible within the limits of an article of this description: suffice it to mention one bath only. The Aix douche

*Graves.*] [*Harrogate.*

FIG. 5—The Aix douche.



[*Graves.*] [*Harrogate.*

FIG. 6.—The Vichy douche.

has the effect of increasing the amount of urea eliminated, and the excretion of uric acid is markedly augmented, which fact, viewed in conjunction with the diminished production of uric acid resulting from administration of the old sulphur water, explains the happy results obtained in the treatment of gout by the use of this water and bath, the one diminishing the production of the *materies morbi*, the other facilitating its elimination.

In answer to the question first propounded, it would appear then that modern research has not only abundantly justified pre-existing views as to the value of spa treatment, and has to a large extent provided sound reasons for them, but has also considerably extended its sphere of usefulness, and has uplifted the methods from the dead-level of empiricism to the more exalted domain of rational and scientific therapeutics.

The foregoing remarks suffice to show that the home watering places have of late years advanced with the times, and are able to claim equal recognition with the best known continental resorts. The variety of the waters to be found at the different health resorts of this country is such as to cover almost all requirements, and there are few cases indeed which it is really necessary to send abroad. In the matter of baths, also, almost every known balneo-therapeutic procedure is obtainable in Great Britain, and the methods of administration are as carefully supervised and as efficiently carried out as elsewhere. The one element in which we are unable to compete with our rivals abroad is in the matter of climate, for we cannot ensure the same protracted periods of sunshine that many of them enjoy. Nevertheless, the weather experienced during the season at the home resorts is not necessarily incompatible with a successful "cure," and is indeed preferred by many, by reason of its bracing qualities, to the hot and relaxing climates of some of the continental spas.

In estimating the value of spa treatment other factors besides the administration of waters and baths must be taken into consideration; such, for instance, as change of air, rest, freedom from business anxieties or household cares, regular habits of living—early rising, simple moderate diet, and so forth—all of which play their part in achieving the end in view. Therein lies the superiority of spa treatment over ordinary medicinal means in suitable cases, mainly of chronic ailments, and the impossibility of fulfilling these necessary conditions renders futile the attempt to follow out similar lines at the patient's own home. Indeed, by many the major influence is attributed to these factors rather than to baths and waters, and in some cases this may be true. But, while recognising fully their importance, the foregoing rough indication of some of the modes in which waters and baths have been proved to act suffices to show that to these the predominant influence must be assigned.

WILFRID EDGECOMBE.

## THE DOVER MEETING OF THE BRITISH ASSOCIATION.

INTENDING visitors to the Dover meeting should note that this year the chief railway companies afford additional facilities to members of the Association. They offer a return ticket at a fare and a quarter, issued from September 12 to 20, available for return till September 27. Those who wish to avail themselves of this privilege must obtain from the Secretary a signed certificate, which must be given up to the booking clerk when the ticket is purchased. The following railway companies have entered into this arrangement:—The Caledonian, Great Eastern, Great Central, Great Northern, Great Western, London, Brighton and South Coast, London and North Western, London and South Western, Midland, North British, South Eastern and Chatham and Dover. The usual arrangement for places within fifty miles of the place of meeting still holds good, in virtue of which a return ticket at a single fare may be obtained at Dover on production of membership tickets. These tickets are available for return on the same or the following day.

The local programme is now in the press. It may, however, be useful to recapitulate the items of general interest which will appear in the programme.

### SECTIONAL MEETING ROOMS.

A—Mathematical and Physical Science—School of Art, second floor.
B—Chemistry—School of Art, first floor.
C—Geology—College Gymnasium.
D—Zoology—School of Art, second floor.
E—Geography—Apollonian Hall.
F—Economic Science and Statistics—Co-operative Rooms.
G—Mechanical Science—School of Art, ground floor.
H—Anthropology—Rifle Volunteer Hall.
I—Physiology—Chemical Lecture Room, School of Art.
K—Botany—Union Hall.

### PRESIDENT'S ADDRESS AND EVENING LECTURES.

These will be delivered in the Town Hall.

*President's Address.*—On Wednesday, September 13, the first general meeting will be held at 8 p.m., when Sir Michael Foster, K.C.B., Sec.R.S., will assume the presidency and deliver an address.

*First Evening Lecture.*—On Friday, September 15, at 8.30 p.m., by Prof. Charles Richet, of Paris. Subject: "La Vibration Nerveuse."

*Second Evening Lecture.*—On Monday, September 18, at 8.30 p.m., by Prof. Fleming, F.R.S. Subject: "The Centenary of the Electric Current."

### ENTERTAINMENTS AND GARDEN PARTIES.

*Thursday, September* 14.—The Chairman of the College Council, Dr. E. F. Astley, the Headmaster and Masters of Dover College, invite members, associates, and holders of ladies' tickets to a garden party in the College Close, from 3.30 to 6 p.m.

The Mayor, Councillor Sir W. H. Crundall, J.P., and the Mayoress, Lady Crundall, invite members, associates, and holders of ladies' tickets to a conversazione at the Town Hall, from 8.30 to 11.30 p.m.

*Friday, September* 15.—Lord George Hamilton, Captain of Deal Castle, invites two hundred members, associates, and holders of ladies' tickets to visit the Castle, from 3.30 to 6 p.m.

A smoking concert in honour of the President, Sir Michael Foster, F.R.S., will be given by the Local Committee in the Apollonian Hall, Snargate Street, commencing at 10 p.m. A selection of music will be performed by the band of the Royal Artillery from Woolwich, by special permission.

*Saturday, September* 16.—A grand military tattoo will take place on the sea front, opposite Waterloo Crescent, at 9.30. A space will be reserved for members, &c. Admittance on presentation of Association ticket.

*Monday, September* 18.—The Mayor and Lady Crundall invite members, associates, and holders of ladies' tickets to an "at home" at the Connaught Park, from 4 to 6.30 p.m.

*Tuesday, September* 19.—On Tuesday afternoon, September 19, a motor-car exhibition will be opened at the Dover Athletic Grounds by the Mayor.

Lord Northbourne invites 200 members, associates and holders of ladies' tickets to visit Betteshanger Park, from 4 to 6 p.m. Light refreshments will be offered.

Lord George Hamilton, Captain of Deal Castle, invites 200 members, associates and holders of ladies' tickets to visit the Castle, from 3.30 to 6 p.m.

The Local Committee invite members, associates and holders of ladies' tickets to a garden fête in the Granville Gardens, from 9.30 to 11.30 p.m. The band of the Royal Engineers, from Chatham, will, by special permission, perform a selection of music during the evening.

### THE MUSEUM.

The Dover Museum, in the Market Square, is well worth visit, as it contains a large number of objects interesting both to

antiquarians and lovers of natural history. The collections owe much to the care and interest of Dr. E. F. Astley, the hon. curator. The assistant curator will be glad to afford visitors every assistance. The anthropological collection, though small, is interesting, and contains a valuable feathered cloak from the Sandwich Islands, a Maori's head, and many war trophies from New Zealand. The "Plomley" collection of British birds, presented by the late Dr. Plomley, is specially rich in local specimens. The collections have been enriched by many gifts from the Hon. Walter Rothschild, who takes considerable interest in the Dover Museum. There is a good collection of British birds' eggs, including those of the peregrine falcon, once common on the Dover cliffs, but now becoming exceedingly rare. Prehistoric and local antiquities are well represented. The collections of shells, insects and fossils are also noticeable.

### VISIT OF THE FRENCH ASSOCIATION TO DOVER.

On Saturday, September 16, the members of the Association Française pour l'Avancement des Sciences will visit Dover. On their arrival, about 9.30 a.m., they will partake of a light repast at the Lord Warden Hotel. At eleven o'clock there will be a reception at the Town Hall, when addresses of welcome will be delivered. Afterwards various Sectional Meetings will be visited. At 1.30 there will be luncheon in the marquee in the College Grounds. Tickets for the luncheon (price 15*s.*, including wine) will be on sale at the Reception Room. In the afternoon the members of the French Association will visit the Castle and other objects of interest in Dover.

### VISIT OF THE BRITISH ASSOCIATION TO BOULOGNE.

On Thursday, September 21, the members of the British Association will visit Boulogne. A special boat will leave Dover about 8.30 a.m., arriving at Boulogne about ten o'clock. After a reception, the various sections will be visited, and subjects mutually interesting to the two Associations will be discussed. At 12.30 the Municipality of Boulogne will entertain the Associations to lunch. The luncheon will be followed by a Reunion with addresses. In the afternoon a plaque to the English poet Campbell will be unveiled, and a statue to the French man of science, Duchenne, will be inaugurated. The afternoon will be spent in visiting the town of Boulogne. In the evening those members of the British Association who do not intend to take part in the five days' excursion will leave for Dover. Sleeping accommodation will be provided in Boulogne for those who intend to visit the towns of Northern France and Belgium on the excursion commencing the following morning (Friday).

### HANDBOOK.

The Local Committee have prepared a special handbook to Dover and the neighbourhood, containing articles on the history and antiquities, the geology, the entomology, the vertebrate fauna, the botany, the climate, the river and tides, the docks and other engineering works, the trade, commerce, and industries. This book is illustrated with maps and plans, some of which contain new work. The information given in the maps and plans and the articles, written by specialists on the subjects they deal with, will, it is hoped, render the work not only useful on the occasion of the British Association's visit, but also of some permanent value.

### EXCURSIONS.

*Wednesday, September* 20.—Excursion to Canterbury. The Mayor of Canterbury and the Corporation invite the members, associates and holders of ladies' tickets to Canterbury in the afternoon, to meet the President and one hundred members of the French Association. Special facilities will be given for visiting the various places of industry in the city. The Dean and Chapter will receive the guests at the Cathedral after the Mayor's reception at the Royal Museum.

*Thursday, September* 21.—(1) Visit of members, associates, and holders of ladies' tickets to the Association Française pour l'Avancement des Sciences at Boulogne. A special steamer will leave Dover at 8.30 a.m. (2) Excursion to Chatham Dockyard and Rochester Cathedral. Limited to 200. (3) Excursion to Wye Agricultural College, to inspect experimental farm. Luncheon will be provided by the Principal, Mr. A. D. Hall. Guests limited to eighty. (4) A circular tour through the Weald of Kent, including stoppage at about five towns between Dover and Tunbridge Wells, and extending over two days. Limited to fifty persons.

*Friday, September* 22.—There will be a five days' excursion in France and Belgium, to Abbeville, Amiens, Arras, Brussels, Antwerp, Ghent, and Ostend, at the conclusion of meeting. The excursion will start from Boulogne on Friday morning, September 22, when sleeping accommodation will be provided for those not returning to Dover after the visit to the French Association.

### CHURCH SERVICES.

There will be special services at most of the churches on Sunday, September 17. At St. Mary's there will be a special service for members of the Association at 11 a.m., when the Rev. Archdeacon Wilson, D.D. (late Headmaster of Clifton) will preach.

The railway companies will afford facilities for those wishing to visit Canterbury on Sunday. The Very Rev. Dean Farrar (Vice-President of the Association) has arranged the following special services:—

10.30 a.m.—The sermon will be preached by the Lord Archbishop of Armagh.

3 o'clock p.m.—The sermon will be preached by the Rev. Canon Mason, D.D. The sermon will be followed by an organ recital.

6.30 p.m.—The sermon will be preached by the Very Rev. the Dean.

W. H. PENDLEBURY.

## THE NEW PHILHARMONIC MUSICAL PITCH.

THE question of musical pitch has, through the action of some of the leading pianoforte makers, been again introduced into public discussion. That it should end in the general adoption of the French diapason normal hardly admits of a doubt, especially as it is in the United Kingdom only there remain any advocates for the high pitch formerly general. France introduced by law the diapason normal in 1859, and has been gradually followed by Belgium and Italy, Germany and Austria, Russia and the United States of America, leaving this country in musical isolation from which a great effort has yet to be made to bring it into uniformity with other musical countries, so that the note A will be approximately the same here as anywhere else, and not give the impression of a transposition. The difference of vibration number is not so very much; if it were a semitone, it might be easier rectified—at least in concert organs—it may be stated at 3/5, or at most 2/3 of an equal semitone. It is measurement and the important consideration of temperature that justify the admission of a subject, at the first aspect merely artistic, into the columns of NATURE. Temperature has as yet met with insufficient consideration. It is hardly alluded to in the "Sensations of Tone" by Helmholtz; it meets with a bare mention only, although somewhat extended in the footnotes of the English translator, the late Dr. A. J. Ellis, who refers (p. 90, second edition) to the experimental work in that direction of Mr. Blaikley.

It is well known that the Paris diapason normal is stated as $A=870$ vibrations a second at 15° C. As we reckon by complete vibrations, we take this number at one-half (435), with the temperature by the Fahrenheit thermometer (59°). Although this is a very good temperature for open-air music, as military bands, &c., it is not high enough for operas and concerts taking place in confined spaces with audiences and artificial lighting. The opera and concert orchestras have, therefore, everywhere to find their own pitch evolved from the Paris standard to suit an average increase of temperature. If the French Commission had decided upon 20° C. (68° F.), the necessity for an empiric proceeding would have been avoided. They might very well have adopted Scheibler's suggestion, made in 1834 at Stuttgart, of $A=440$. It is known that he worked at a temperature of about 70° F. To him we owe the only facile

tonometer, for which his pitch was really A = 439·5. It is as well to go back to the protocols of the Congress at Vienna in 1885, which led to the adoption of the French pitch in Austro-Hungary. After a unanimous acceptance of the diapason normal at 15° C. it was proposed that, in order to keep the wind instruments in performance to the initial standard vibration number A = 435, the brass and wood wind instruments, and also the organ, should be made for 24° C. (75·2 F.)!—thus introducing a second standard to be used concurrently with the first, the necessity attributable to the vibration number being increased automatically by the heating and rarefaction of the air increasing its velocity, and with the orchestral wind instruments by the breath and handling of the players. Mr. Blaikley has shown the velocity of air in pipes is always less than in free air, possibly through the friction of the walls, but in the organ flue pipes it comes so near to free air that the organ may be almost regarded as a thermometer. So high a temperature as 24° C. was not left unchallenged; a wiser determination was urged of 20°, which in practice would have proved right. However the great differences likely to arise in average temperatures due to climatic conditions, and to warming and lighting apparatus, as, for instance, gas or electricity, prevented a decision from being arrived at; so that Vienna is now, as London was pending the decision of the Philharmonic Society, using a convenient empiric pitch of about A = 440 for concert performances. Ingenious as the Viennese plan in 1885 would have been, it is wiser to have one standard with one note, A, for its expression, and one mean temperature. For brass instrument makers a B flat fork may be used, and to suit the old custom of organ-builders and pianoforte-makers, a C fork; but in preparing them equal temperament should be rigidly observed.

In 1879, at the instance of Mdme. Adelina Patti, the Covent Garden Opera adopted French pitch; a recent trial in performance satisfied me that it was at A = 440, the temperature being about 70° F., and that there had been no departure from the intention of using the French standard. Little notice has at any time been taken of this important change at the Opera; but when the Queen's Hall was opened in 1893, Mr. Newman, the manager, and Mr. H. J. Wood, the conductor, lost no time in introducing the diapason normal for all performances for which they were responsible; the proprietors going to the expense of having the organ, which had just been built at the high pitch, lowered. Mr. Henschel, in his symphony concerts at St. James's Hall, and in founding the Scottish orchestra, speedily followed. But the decisive point for this country was reached when, in July 1896, the Philharmonic Society, the most eminent musical institution in this country, elected to adopt the French diapason normal, and in the following November decided to have a standard tuning-fork for their concerts. Having consulted me, the directors accepted my suggestion for that pitch that it should be A = 439 at 68° F. Forks made for the Society by Valantine and Carr, of Sheffield, were verified by me with the aid of the Scheibler tonometer in the Science Department, South Kensington, and besides the one retained by the Society, accurate copies were presented by the directors to the Science and Art Department, the Society of Arts, the Royal Academy of Music, the Royal College of Music, the Guildhall School, Trinity College, London, and myself; the last being accessible on all lawful days at Messrs. John Broadwood and Sons, 33 Great Pulteney Street, W. The B flat is stated in the same minute of the Society as = 465, the C = 522; this last happens to be a just minor third above A = 435, an accidental, although useful, coincidence.

The vibration number 439 is really the French standard raised to an average performing temperature, theoretically by my coefficient of a thousandth part of a complete vibration a second for one degree Fahrenheit, so that for 435 the rise for the next degree is ·435. In a variety of ways I have sought an average concert temperature which I have finally taken at 68°, at which strings, wind, organ and piano should be in tune. According to my coefficient A = 435 at 59° should be A = 438·93 at 68°. The round number 439 is more convenient. Briefly expressed, my coefficient is ·5 per degree for C = 500; nearly, if not quite, the rise in free air. According to Helmholtz, the velocity of sound in dry air is at 0° C. (32° F.) 322 metres = 1089·3 feet, say 1090; according to Dr. Ellis, at 60° F. the velocity is 1200 feet per second; with this my coefficient practically agrees. In further justification, I quote the Covent Garden A = 440; the same vibration number for pianos, communicated to me by Herr Seuffert (Bösendorfer's), Vienna; the clarinet of Herr Mühlfeld, of Meiningen and Bayreuth, A = 439·5, it being understood when warm; a complete trial of all the wind instruments of Mr. Henschel's orchestra with a piano tuned to A = 439 in a room exactly at 68° F.; and lastly, the crowning triumph of the Lamoureux orchestra from Paris joining forces with the Queen's Hall orchestra in London this year, the accuracy of pitch in the performance being unassailable, A = 439! I should like to add for organs my trials of the St. James's Hall organ, at 52° C = 531 and at 72° C = 541, as one of many comparisons of this nature; and conclude with Prof. Blaserna's report of a trial at Vienna, 1885, when A = 435 at 15° C., warmed to 30° C., became A = 457·7, equivalent to raising A to a tempered B flat. If a piano were supplied for a concert intended to be French pitch, at the standard fork A = 435, in London or Paris, Berlin or Vienna, it would be too flat for performance. It would be a concession of great importance, which the musical world could not be too grateful for, if the Paris diapason normal were revised for the higher temperature, 20° C., and legalised A.D. 1900, for France at A = 439. Our Philharmonic Society has shown the way, the rest of the world would soon follow. Neither the stability of pitch of the tuning-fork nor that of a pianoforte during a concert need be considered. Dr. Ellis gives the flattening of tuning-fork as 1 in 16,000 per degree Fahrenheit; Mr. Blaikley and myself in one trial only of a concert pianoforte, ·025 per degree; but for the short time a concert lasts this must be imperceptible, the elasticity of the music wire having to be reckoned with against the least change of tension.

The objections to the A = 439 that have been urged are that wind instrument makers may take it as a starting point for a lower temperature than 68°, but not if they are conscientious? We can legislate for this no more than we can for the tendency to exceed the present high pitch, as is shown by our military bands and the majority of the brass bands in this country, in spite of Kneller Hall, which is bound to maintain the old Philharmonic pitch until the War Office releases the army from it and provides or sanctions French pitch bands. Organ-builders who can work with accurate forks and a thermometer will have no difficulty with the French pitch—indeed, nearly all are in favour of it, as are the pianoforte-makers and dealers generally, but there are some who seem to fear their instruments will suffer in brilliancy of effect by the reduction. When, however, we consider the rise in the tension of pianos during the last thirty years, due to improvement in music wire and to a great change of construction, causing in grand pianos a rise in tension equivalent to a minor third in pitch, or more; and when we reflect that the difference of pitch proposed in tuning to the new Philharmonic is only 3/5 of an equal semitone, we may see in the change more a gain than a loss by a possible increased fulness of tone-quality, and above all we shall have uniformity with the rest of the musical world.

A. J. HIPKINS.

## RIBBON AND DARK LIGHTNING.

MR. ALEX. MORTON, secretary and librarian of the Royal Society of Tasmania, has sent some photographs of lightning flashes taken by Mr. W. Aikenhead, one of which is here reproduced. The photographs were taken at night with a hand camera. Referring to them, Mr. Aikenhead remarks:—"The thunderstorm was an unusually severe one, and the atmosphere surcharged with electricity, as evidenced by the frequency and extraordinary vividness of the lightning flashes, whose brilliancy momentarily rendered objects, even at a distance, as clearly discernible as in daylight. The intensity of the 'triple' flash—of which I was so fortunate as to secure a counterfeit—was so great that for some moments I was completely dazzled. I may mention that the thunderstorm lasted fully an hour, and was at its height about 9 o'clock; and it was at this period the exposures were made with my camera."

The accompanying picture is interesting on account of the triple flash represented in it, and the dark lines apparently radiating from it. In an article printed in NATURE several years ago (vol. xlii. p. 151, 1890), Mr. Shelford Bidwell described each of these characteristics of photographs of lightning flashes, and gave explanations of them. He remarked that in nearly, if not quite, every case where broad ribbon lightning has been photographed, the camera was held in the operator's hand—a fact which naturally suggests the idea that the widened image of the flash may be due to the movement of the camera during exposure. Though it might be impossible to move the camera appreciably in the brief duration of a single lightning flash, several flashes sometimes pass in quick succession over the same path, so that they may appear side by side upon the photograph if the camera is shifted during their occurrence. Moreover, Mr. Bidwell pointed out that lightning sometimes leaves a kind of phosphorescence along its track, and this may last long enough to produce a photographic picture, even though the flash itself was instantaneous. A photograph of a triple lightning flash reproduced in NATURE of October 13, 1898 (vol. lviii. p. 570) furnishes decisive evidence that a camera can be moved quickly enough to obtain several pictures of a single luminous track of lightning. The three flashes shown in that picture are identical in shape, and it is estimated that they followed one another along the track with a frequency of about 30–35 per second.

But while it is certain that some photographs of multiple and ribbon lightning are produced by movement of the camera, others represent actual lightning of a broadened or multiple form. Commenting upon some photographs of ribbon lightning obtained by the Rev. J. Stewart-Smith, Prof. Cleveland Abbe remarked in the U.S. *Monthly Weather Review* of August 1898 that he thought that they were not taken by moving the camera during exposure. He considered that a discharge of lightning was too fleeting to be influenced by the motion of the camera. With artificial oscillatory discharges the time of the discharges and the motion of the sensitive film might be so controlled as to produce the appearance of a ribbon; but no motion of the camera seemed likely to explain the many details in the ribbon photographs of natural lightning described. Prof. Abbe thought, however, there was one flash on Mr. Stewart-Smith's plate that had every indication of being certainly an oscillatory discharge, showing lines of flow identical with those photographed by Prof. Trowbridge at Cambridge, Massachusetts, and fully maintaining his conclusion that the lightning flash is an oscillatory discharge repeated frequently to and fro within the crack in the air that is opened by the first discharge.

That lightning flashes can actually present a ribbon-like appearance, and have an appreciable duration, is borne out by a letter which was sent to the Royal Society from Buluwayo at the end of 1895, and was printed in NATURE of January 23, 1896 (vol. liii., p. 272). The writers state that they were sitting in a room when one of them called attention to a very bright lightning flash. "All of us promptly went to the door, whence we witnessed a truly extraordinary sight in the shape of three ribbons of a greenish-white lightning, which hung in the sky, motionless, for what must have been fifteen to twenty seconds. It seemed to be a long way off (in a north-westerly direction), as we heard no report of thunder whatever. There could be no mistake about it—it was as distinct as possible, and it must have lasted fifteen seconds *at least*." With evidence of this kind to consider, the reality of the ribbon appearance cannot be doubted. To obtain more definite information concerning this form of lightning and the nature of the electric discharge in an ordinary lightning flash, systematic attempts should be made to photograph lightning with cameras having a known rate of movement, and an

Photograph of lightning taken at Devonport, Tasmania, by Mr. Aikenhead.

arrangement for determining the angular diameter of the ribbon.

As to the dark ramified flashes shown upon the accompanying picture, Mr. A. W. Clayden has shown by experiment that they are due to photographic reversal. If the lens of a camera is covered up immediately a flash has been photographed, the flash comes out bright in the ordinary way in the print; if, however, the lens is allowed to remain uncovered for a minute or so, thus exposing the plate to the diffused light of the sky or the glare of other flashes, the original flash appears black upon the final print.

In the same way, the discharge of an electrical machine can be made to appear dark in a photograph by leaving the lens uncovered for about a minute after the discharge has imprinted itself upon the plate. According to this, the dark ramifications in Mr. Aikenhead's picture represent a discharge of lightning which occurred before the bright triple flash. The glare of the bright flash and the

diffused light of the sky caused the photographic reversal of the first image.

Photography thus gives no support to the view that dark lightning has a real physical existence; and Lord Kelvin's letter printed in NATURE of August 10 (p. 341), together with that by Dr. W. J. Lockyer in last week's number, show conclusively that when it is visually observed it is an effect due to fatigue of the retina.

## THE RECENT ERUPTION OF ETNA.

PROF. A. RICCO, Director of the Etna Observatory, informs us that on July 19, at 8 a.m., Mount Etna threw out from its central crater an enormous mass of vapour, stones, lapilli, and cinders, which were lifted to a height of several kilometres, and afterwards covered all the south-east slope of the volcano as far as Zofferana Etnae (altitude 600 m.), where the roads are covered by nearly a centimetre of volcanic ash. A number of stones struck the dome of the Etna Observatory (which is about a kilometre from the central orifice), so that about thirty holes were made in the iron plates, six millimetres in thickness, which cover this dome; five of these holes have a diameter of 30 centimetres, and the stones causing them fell into the observatory containing the refractor. Two stones also pierced the floor, and embedded themselves in the basement; and one broke three steps of the observing chair. Another pierced the wooden base surrounding the foot of the refractor; fortunately, this and the other apparatus of the observatory received no damage. Two other stones passed through the roofs of the side-rooms.

Round the observatory there are about fifty holes, caused by the fall and penetration of the stones in the sandy soil.

A heap of straw which was near the stables of the observatory was reduced to ashes, which proves the high temperature of the eruptive materials; moreover, holes were also burnt in the wooden flooring where it had been pierced by stones.

The steam of the eruption condensing in the air gave place to a warm and acid rain in the higher parts of the volcano, and lower down it caused ordinary rain.

The column of steam had by nine o'clock spread itself enormously in the sky nearly over Catania (a distance of 30 km.), and caused a marked darkening. By 9.30 the column had disappeared.

The eruption was accompanied by no perceptible movement of the earth, except a slight shock at the lower end of the Valle del Bove. The instruments at Catania only indicated a very slight oscillation. At the Etna Observatory two seismometers showed horizontal and vertical movements. The eruption was also accompanied by detonations, which were heard very slightly as far as Catania.

On July 25 there occurred a similar eruption, but of less importance.

## PROFESSOR BUNSEN.

ON Wednesday morning, August 16, the illustrious Heidelberg chemist breathed his last, after a long life wholly devoted to the furtherance of science. In April 1881 I communicated to the columns of this journal a sketch of the work of him whose death at the ripe age of eighty-eight all lovers of science now have to deplore. We can only now call attention to the magnitude and extent of that work, and lay on the grave of one of the truest and noblest of men the tribute of our admiration and respect. As expressing the position held by Bunsen amongst the standard-bearers of science, I may, perhaps, be forgiven for quoting the opening sentences of what I wrote eighteen years ago, as I cannot find more appropriate words to indicate what all feel who know what his work was.

"The value of a life devoted to original scientific work is measured by the new paths and new fields which such work opens out. In this respect the labours of Robert Wilhelm Bunsen stand second to those of no chemist of his time. Outwardly the existence of such a man, attached, as Bunsen has been from the first, exclusively to his science, seems to glide silently on without causes for excitement or stirring incident. His inward life, however, is on the contrary full of interests and of incidents of even a striking and exciting kind. The discovery of a fact which overthrows or remodels our ideas on a whole branch of science; the experimental proof of a general law hitherto unrecognised; the employment of a new and happy combination of known facts to effect an invention of general applicability and utility; these are the peaceful victories of the man of science which may well be thought to outweigh the high-sounding achievements of the more public professions."

In the columns which follow the above will be found a statement of the chief experimental researches which have not only raised Bunsen by the common consent of all who can understand the results of accurate and far-reaching methods to the highest point of scientific honour, but also of those more popular discoveries which have made his name a household word in circles far wider than those of purely scientific appreciation. Now, therefore, it is only necessary to recall the main facts of his life work; to note, in the first place, that his desire to unravel the secrets of nature was unalloyed by any attempt to make capital out of any application of his discoveries. "To one man," he often said, "comes the duty of discovery, to another that of applying that discovery to practical uses." Like our great countryman Faraday, Bunsen consistently refused to be drawn away from the paths of purely scientific investigation, and, though too clear-sighted a mind to belittle the importance of the application of scientific discovery to every-day life, rightly judged that to him belonged the undoubtedly higher and nobler work of enlarging the boundaries of knowledge.

The next thing to be noted about Bunsen's work is its originality and its accuracy. It matters not whether we look into his purely chemical investigations, at his chemico-geological researches, or at those—perhaps the most remarkable amongst the many questions he answered—which lie on the borderland of physics and chemistry, in every case we rise from the study not merely feeling that we have to do with a master's mind and hand, but that each investigation is stamped by an original mode of treatment and by an accuracy of thought and of manipulative power which, it is not too much to say, has rarely if ever been equalled.

In no instance was this rare combination of mental and manual dexterity more strikingly shown than in his investigation of the compounds of cæsium, the rarest of the two alkali metals which he discovered by means of spectrum analysis. In order to prepare the pure salts of this metal, some scores of tons (I write this away from books, and therefore cannot give the exact figures) of Dürkheim mineral water had to be evaporated, and from this residue it was only possible to obtain some five or six grams of the pure chloride. Nevertheless, from this comparatively minute quantity Bunsen succeeded not only in preparing and analysing all the important salts of cæsium, but in ascertaining by goniometric methods their exact crystalline form. So that he was able to supply all the information requisite to a complete understanding of the position of this new element and its compounds to those of its well-known relations potassium and sodium.

Then look at his gasometric methods. He was the first to attempt anything like exactitude in the measurement of

gases. And when he had perfected his methods, no improvements as regards accuracy were forthcoming. Other quicker and, perhaps, more handy processes have since come into vogue; but it was Bunsen who taught men how to handle and to separate and measure gaseous substances.

Next take his researches in chemical analytical methods. There we find again that all he touches he adorns. Whether in the delicate and complicated silicate analyses, in blow-pipe work and flame reactions, in volumetric methods, in separations of closely allied metals, such as antimony and arsenic, or those of the cerite earths, we see the same master's touch. Then his physico-chemical researches, his ice-calorimeter, his photo-chemical investigations, about which I am able to speak with special authority; his methods of ascertaining the specific gravity of gases by their rates of diffusion, and many other distinct lines of research, all well known and recognised as classic, exhibit the same wonderful power.

About his more popularly-known discoveries it is not necessary here to speak, save to say that the Bunsen battery and the Bunsen burner have rendered his name a household word all the world over, whilst his application of spectrum analysis to the investigation of terrestrial matter has done more than all the investigations of past time to increase our knowledge of the chemical composition of the earth's crust.

But this experimental work, great and important as it is, is not the greatest or most important work which he accomplished. It is as a teacher and as an example that the name of Bunsen is and will be chiefly honoured and remembered. It is only those who have had the benefit of working under and with him who can fully understand the feelings of affection and respect with which they regard his memory. To those who had the privilege of his intimacy, of whom I can happily lay claim to be one, his friendship will remain as an abiding source of gratification. As an investigator he was great, as a teacher he was greater, as a man and a friend he was greatest.

HENRY E. ROSCOE.

## NOTES.

THE Royal Society has received through Mr. Chamberlain the following memorandum by the Governor of the Straits Settlements:—

The Government of the Straits Settlements desires to invite the attention of Radcliffe's travelling Fellows, and of holders of scholarships for medical and physical research, to the study of the tropical disease called Beri-beri. This disease caused in the hospitals of the Colony 730 deaths in 1896 and 692 in 1897. This Government will be glad to assist any scholar who desires to engage in the scientific investigation of this disease in the Colony by providing him with furnished quarters, rent free, by giving him free access to all the hospitals and facilities for studying the cases therein, by defraying the cost of his passage to the Colony, and in any way which may be agreed upon hereafter between the scholar and the undersigned.

By Command of the Governor,

J. A. SWETTENHAM,
Colonial Secretary, S.S.

Colonial Secretary's Office,
Singapore, July 20.

It may be added that Dr. Hamilton Wright, late of Montreal, has recently been appointed pathologist to the Straits Settlements. He will be provided with an adequate laboratory, on the furnishing of which he is now engaged. The opportunities for pathological research will therefore be extremely good.

THE eighteenth annual Congress of the Sanitary Institute was opened at Southampton on Tuesday, when about seventeen hundred delegates attended. Sir William Preece, K.C.B., the president, delivered his inaugural address, in which he dealt with the principles underlying practical applications of sanitary engineering.

MR. A. H. MILNE, hon. secretary of the Liverpool School of Tropical Diseases, informs us that in response to a request from Major Ross that workers should be sent out to join him at Sierra Leone, the school is despatching, as an assistant to him, Dr. R. Fielding Ould, of the Liverpool School of Pathology, who has had special experience in private bacteriological research. It is to be hoped that the Government will take the matter in hand, and will help the work of the expedition.

WE learn from *Science* that Dr. A. B. Meyer, Director of the Dresden Museums, is now in the United States on a commission from the Saxon Government to inspect American museums before the new buildings are erected at Dresden. He is accompanied by Prof. P. Wallot, who is one of the international commission of architects selected to decide on the plans of the University of California in accordance with Mrs. Hearst's arrangements.

A *Reuter* telegram from Potsdam states that the new observatory and the great refractor, recently erected at the Astrophysical Observatory there, were inaugurated on Saturday, August 26, in the presence of the German Emperor.

OUR photographic readers may be reminded that all entries for the Royal Photographic Society's forty-fourth annual exhibition, to be held at the Gallery of the Royal Society of Painters in Water Colours from September 25 to November 11, close on Wednesday, September 6, at 9 p.m.

THE Allahabad *Pioneer Mail* states that an Austrian scientific party will visit India towards the latter end of October to observe the display of Leonid meteors which will take place in November. Two observation stations are to be fixed at Delhi, some five miles apart, telephonic communication being maintained under arrangements made by the Telegraph Department.

DR. A. CANCANI, formerly assistant at the geodynamic observatory at Rocca di Papa, has been selected to succeed Dr. G. Agamennone as assistant in the central office of meteorology and geodynamics at Rome. Dr. Cancani is well known to seismologists for his work in connection with the velocity of earthquake-waves, and for the improvements which he has made in the pendulums designed for recording the undulations from distant earthquakes.

REFERENCE has already been made to the fact that the section of the tree under which Dr. Livingstone's heart was buried, containing the inscription carved by his followers, has been obtained for preservation in the Royal Geographical Society's collection of relics. The *British Central Africa Gazette*, published at Zomba, gives the following particulars of the journey to obtain the section:—Mr. Codrington, Deputy Administrator for the British South Africa Chartered Company north of the Zambesi, left Fort Jameson (Mpezeni's) on April 24, and reached Chitambo on May 9. From the present village of Chitambo he travelled with Chitambo ten miles E.S.E., three miles to the Msumba river or swamp, and then seven miles to the Luwe river. These streams flow into the Lulimula river, and that into the Luapula. Chitambo states that his father was interred under the *Mpundu* tree close to the spot where Livingstone's heart was buried. The following measurements were taken of the tree: Round base, 13 feet 5 inches; round bottom of inscription, 10 feet 1 inch; round top of inscription, 10 feet; height of bottom of inscription from ground, 4 feet 5 inches. The bark was cut off by Livingstone's men in order

to enable the inscription to be carved, and it has now grown over part of the letter "E" in Livingstone and over the number "3" in 1873. Livingstone's *Mpundu* tree was too old to give seeds, so it was not possible for Mr. Codrington to bring away any of these. After the tree had been cut down, and the section containing the inscription carefully removed, a tall iron telegraph pole was erected in the entre of the stump and carefully secured. This, together with the various observations taken, will suffice to mark the exact spot until a suitable monument may be erected. The altitude (by boiling point) at the *Mpundu* tree was found to be 3877 feet above sea level.

MR. W. WELLMAN and the American members of his polar expedition arrived at Hull on Tuesday from Tromsö. In addition to the information published in last week's NATURE (p. 399) concerning the results of the expedition, the following particulars were given by Mr. Wellman to a representative of Reuter's Agency:—"The point at which we turned back was about twenty-five miles north-west of the Freeden Islands, where Dr. Nansen landed in 1895, and north of these islands we saw and took the bearings and photographs of three islands and a large land, none of which had been seen by either Payer or Nansen. We were also able wholly to clear up the mystery of Payer's so called Dove glacier, which simply does not exist, as Dr. Nansen had in part shown. In addition to this useful geographical work, greatly augmented by subsequent journeys under Messrs. Baldwin and Harlan, these two gentlemen and Dr. Hoffmann, the naturalist, did some valuable scientific work which will, I feel sure, attract much attention when elaborated and reported in proper form. I still believe it possible to reach the North Pole by Franz Josef Land, but whether or not I shall make another effort in that field I am unable to say." After Mr. Wellman's return to headquarters on April 9 Mr. Baldwin again took the field, leaving camp on April 26, accompanied by the four Norwegians, this party having twenty-six dogs and two sledges, carrying provisions for three weeks. Their object was to examine the unknown region to the eastward of Wilczek Land. They were enabled to chart the entire eastern as well as north coasts of that land. Thirteen miles further east they discovered a large ice-covered island nearly as large as Wilczek Land and extending to 64° E. longitude. Several smaller islands were also discovered during this journey. The newly-discovered land was named Graham Bell Land, after the president of the National Geographical Society of America. Another exploring journey was made by Mr. Harlan, and later a trip by steamer, the result being a fairly complete survey of the unknown and unmapped parts of the archipelago.

THE practical application of the Röntgen rays to the needs of medicine and surgery formed the subject of the presidential address recently delivered before the Röntgen Society by Dr. C. M. Moullin. There is no branch of medicine or surgery which does not afford abundant evidence of the improvements which have taken place in the production and utilisation of the Röntgen rays in the course of the past year. Dr. Moullin points out that the fluorescent screen has now reached such a degree of perfection that with suitable apparatus the minutest movement of the heart and lungs, and the least change in the action of the diaphragm, can be watched and studied at leisure in the living subject. In short, Dr. Moullin testifies that there is scarcely any change in connection with the lungs and the heart and great vessels which cannot now be seen and photographed, scarcely a disease of the chest or of the organs which it contains concerning which the most valuable information cannot be obtained. To such an extent has the fluorescent screen been improved, and so easy has investigation with it been made, that it is probable that some day the examination of a patient's chest with it will be considered as much a matter of routine and as little to be neglected in all doubtful cases as an examination with the stethoscope is at the present time. Valuable as are the indications given by the ophthalmoscope in obscure diseases of the brain, they are not to be compared with those which can be obtained by systematic and skilled use of the fluorescent screen in diseases of the heart and lungs.

THE benefit which surgery has derived from the improvements which have been effected in the use of the Röntgen rays during the past year is, Dr. Moullin states, no less striking than that gained by medicine. As might be expected, the largest proportion and the most striking cases have been furnished by the injuries and diseases of bones and joints. With a well-lit fluorescent screen the nature of an injury can be seen at once, and, what is even more valuable, it is no less easy to ascertain whether a fracture is properly set or a dislocation completely reduced. If the screen is of service to physicians in the diagnosis of intra-thoracic disease, the records of the past year have shown by numberless instances that it is no less valuable to surgeons by enabling them to make sure at a glance that the bones are in their proper relative situation without touching the splints or giving the patient a moment's pain. So far as surgery is concerned, Dr. Moullin remarks, nothing illustrates the immense improvement which has been made in radiography in the course of the past year better than the detection of renal calculi. Until this year the instances in which they had been photographed and verified by operation were few and far between. Now, thanks more particularly to the work of Mr. Mackenzie Davidson in this direction, the detection of renal calculi can be looked forward to with a fair degree of certainty, and, what is even more valuable, as saving patients from unnecessary operation, the evidence can be trusted equally well when it is negative. In all ordinary cases it may be said that if no calculus is seen there is no calculus there to see.

FROM reports in the *Agricultural Journal*, published by the Cape Department of Agriculture, it appears that much success in exterminating locusts by inoculation with the locust disease fungus has been attained in many districts. The fungus is prepared and supplied by the Director of the Bacteriological Institute, Graham's Town, at a cost of sixpence per tube to all applicants residing in Cape Colony. One of the reports upon its use states that over a hundred locusts which were inoculated with fungus disease were distributed amongst a swarm, and on the next morning and the following days large numbers of dead ones were in the sand dunes, being killed by the fungus, as microscopical examination and further experiments with the bodies proved. The growth of fungus from the dead locusts produced a fungus more rapid in growth but smaller in size than the Government fungus. In another case, the fungus was mixed in lukewarm water, and young locusts were released after immersion in the liquid. After three days rain fell, and on the afternoon of the fourth day locusts were found in heaps in the bushes about three miles from where they were immersed. Districts in which no such measures are being taken are much more infested with locusts than those where the fungus treatment is adopted.

SEVERAL articles and notes upon india-rubber and the india-rubber industry in various parts of the world are contained in Nos. 147-150 of the *Bulletin* of the Royal Gardens, Kew, just published. A paper by Prof. Tilden on the spontaneous conversion of isoprene into caoutchouc is reprinted, and it is pointed out that the result represents a step towards the artificial production of india-rubber commercially. Prof. Tilden has not yet been able to bring about this change at will. His observations show that the polymerisation proceeds very slowly, occupying several years, and all attempts to hurry it have resulted in the

production, not of rubber, but of colophene—a thick sticky oil, quite useless for all the purposes to which rubber is applied. The *Bulletin* publishes correspondence showing how the falling off in the production of rubber at Lagos is due to the reckless way in which the trees have been exhausted. The rubber is collected from the Ire tree (*Kickxia africana*), and has been an important source of wealth to the Colony; but the industry is rapidly decreasing, owing to want of control over the collectors who tap young trees, and destroy rubber forests by over-working. In Madagascar efforts are now being made to establish plantations of rubber-producing plants. The island has long been known to furnish a supply of india-rubber to commerce, the rubber being obtained until a few years ago from species of Landolphia—the rubber-vines, which are so widely distributed in tropical Africa About 1892 another source of rubber was exploited, but unfortunately both the trees and shrubs producing rubber have been ruthlessly destroyed, and it is necessary to take active steps to cultivate rubber plants to preserve the industry. The May and June *Bulletin* contains correspondence which indicates the actual source of Peruvian india-rubber. According to the information received, the Caucho tree of Peru is a Castilloa.

*Bulletin*, No. 56 (April 1899), of the West Virginia Agricultural Experiment Station, Morgantown, consists of a report on investigations to determine the cause of unhealthy conditions of the spruce and pine from 1880–1893. This is one of the admirable series of reports which are now issued regularly in many parts of the United States, in order to cope with the immense destruction wrought by insects in that country, resulting, during the fourteen years mentioned above, "in the death and total loss of many hundred thousand dollars' worth of the finest timber in the State" of Virginia. Entomology is no child's play in the States, and Prof. Hopkins enumerates 197 species of insects, observed by himself as infesting the spruce and pine, about half of which are injurious, the remainder being beneficial as parasites of the destroyers, or indifferent. These belong to all orders of insects except Orthoptera, and we imagine that a careful search would be able to fill up this gap by the discovery of some Blattidæ, at least, under loose bark, or in similar situations. Most of the mischief, however, is done by wood-boring beetles, of which, and of their curious burrows, many illustrations are given. There is also an illustration of a portion of a black spruce tree eight inches in diameter, which had been slightly injured, when a colony of large black ants (*Camponotus pennsylvanicus*) took possession, and hollowed out the trunk till the heart-wood was completely destroyed, and the tree fell. This report should be of great interest both to entomologists and foresters, for our own conifers are liable to the attacks of a large number of insects congeneric with many of those here mentioned, though others (as for instance *Camponotus*, just referred to) do not inhabit this country.

IN the U.S. *Monthly Weather Review* for May, there is a useful summary of the climatology of the Isthmus of Panama, by Brigadier-General H. J. Abbot. The first Panama Canal Company made daily observations at Colon, Gamboa and Naos during the years 1882–7, from which it is seen that the temperature differs very slightly during the year. At Colon the mean of the absolute maximum temperature varies from 89°·6 in February to 91°·9 in October; and the absolute minima from 68°·4 in January and April to 70°·5 in October. At Gamboa the absolute mean maximum was 97°·5 in June, and the minimum 59°·4 in February; and at Naos these means were respectively 96°·3 in June and 66°·7 in March. Throughout the whole Isthmus the rainy season begins with May; owing to the northward advance of the layer of rising air, a diminution takes place in July, in the interior, but is subject to the delay of one month on the Pacific side and of two months on the Atlantic side. A second maximum occurs at the end of September in the interior, but at the end of October on the Pacific coast and in the middle of November on the Atlantic coast. Then comes the dry season, which begins everywhere about January 1, and continues for four months. The mean annual rainfall is 120 inches on the Atlantic coast, 93 inches in the interior, and 62 inches on the Pacific coast. Although the rainfall is large, it is comparable with the amounts registered in the United States near the Gulf of Mexico. The paper contains a number of fragmentary observations referring to other periods, for which hourly or monthly variations from mean values have been calculated.

WE have received from the Observatory of Manila, of which the director is Father J. Algué, S.J., a volume (pp. xvi + 192, 4to) entitled "Las nubes en el Archipiélago Filipino." The observatory was one of the institutions invited by the International Meteorological Committee to take part in the special observation of clouds during a year ending May 1897. The volume in question, owing to delay in preparation of the necessary instruments, contains results from June 1, 1896, to July 31, 1897. The work is divided into two parts, giving (1) an account of the principal nephoscopes and theodolites in use, and the results obtained in the Philippine Islands by means of some of them; and (2) an explanation of the methods used in the photogrammetric measurements of the heights and velocities of the clouds, and the valuable results obtained at the Manila Observatory. The volume also contains an interesting account of the importance of the observation of the movements of upper clouds for the purpose of storm prediction.

THE "Eight Queens Problem" is the problem of finding the different ways in which eight queens might be arranged on a chess-board so that no two should be in check of each other; in other words, the number of ways of arranging eight pieces so that no two shall be in the same row, column, or line parallel to a diagonal. This problem, which has occupied the attention of Nauck, Gauss, Günther, Glaisher, Rouse Ball, and Pein, forms the subject of a paper by Dr. T. B. Sprague in the *Proceedings* of the Edinburgh Mathematical Society. There are ninety-two solutions, but these are not all independent, for in general each solution gives rise to four altogether by simply rotating the board, and this number is doubled by taking the reflections of these in a mirror, the exception to this rule being when the pieces are symmetrical about the centre. Mr. Sprague considers the general problem for a board of $n^2$ squares. This problem was reduced to one in determinants by Günther and Glaisher, thus: if a determinant is constructed in which terms in lines parallel to one diagonal are represented by the same letter, and those in lines parallel to the other have the same suffix, the solutions are the terms of the determinant in which no letter or suffix occurs twice. The solutions for squares with one to ten squares in a side were given by Pein, and the ten-sided square possesses 724 solutions. Mr. Sprague has now given the solutions for an eleven-sided square, which are 2680 in number, but he considers it would be necessary to obtain the co-operation of a number of persons in order to classify the solutions for larger squares.

VERY little has hitherto been recorded in regard to the life-history of those peculiar North American rodents locally known as Sewellels, and scientifically as *Haplodon*. It is therefore satisfactory to have a description of the habits and environment of one of the species, from the pen of such an accurate observer as Dr. D. G. Elliot, in the March issue of the *Publications* of the Field Columbian Museum. The Sewellels, which constitute a somewhat isolated family by themselves, are animals of the size of a small rabbit, but with a more beaver-like appearance

and coloration, although short-tailed. The species inhabiting the Olympic Mountains is known to the natives as the "Mountain Beaver," or "Farmer," the latter being the title most commonly employed. Retiring in its habits, it keeps to wet and swampy places in the neighbourhood of small streams, making its burrows in the banks of the latter. Although when in the bushes its movements appear to be exceedingly quick, yet when in the open it is rather slow. These animals obtain their name of "Farmer" from their habit of making "hay." They usually excavate their burrows in the vicinity of a certain water-plant, apparently a kind of low-growing water-lily. The stems and leaves of this plant the little rodents cut down in large quantities and convey to the mouths of their burrows, where, after being spread out to dry in the sun, they are finally carried into the interior to be used as food and bedding.

IF the history of "type specimens," on which museum curators now set so much store, were written, portions of it would read almost like a romance. A case in point is afforded by Dr. Jentink's account of the rediscovery of the type of the peculiar Malagasy carnivore *Fossa daubentoni*, published in *Notes of the Leyden Museum* for October last. In 1872, Gray, after searching the Paris Museum, came to the conclusion that the type described by Schreber was irretrievably lost. Subsequently, however, an imperfect skull turned up in the Paris Laboratory of Comparative Anatomy, which it was thought might belong to the missing specimen. And now Dr. Jentink has discovered in the Leyden Museum a skin with a cast of the Paris skull placed in it, which is undoubtedly the long-lost specimen. It is stated to have been received from Paris in 1835, and appears to be one of the results of an exchange effected by Temminck and Schlegel, who visited the Paris Museum in that year. Incidentally Dr. Jentink shows that "Fossa" is the proper native name of the animal in question, and that it is not applicable to the *Cryptoprocta ferox*, of which the Malagasy title is "Farassa." This alteration should accordingly be made in our text-books.

IN the July and August numbers of the *Zoologist*, the editor, Mr. W. L. Distant, gives the first two instalments of what promises to be a very interesting discussion on "mimicry." Till the communication has reached a more advanced stage, it will obviously be impossible to learn the author's general views on a very difficult and very important subject; but it may be noted that he intends to divide the alleged cases of mimicry into those considered as "demonstrated" and those classed as "suggested or probable," after which we may expect a fuller discussion on the whole subject. In the first section of his communication Mr. Distant takes up the case of the Stick-Insects (*Phasmidae*), and discusses their bearing on the mimicry theory. These insects, he states, are usually considered as undoubted examples of protective resemblance due to natural selection. If, as has been asserted, they are represented in the Carboniferous, they must be the result of an antecedent evolutionary process. Further, the presence of imitative *Phasmidae* in the Carboniferous implies the existence of enemies, probably reptiles, and possibly transitional forms of bird-life. Thus mimicry must be of very ancient origin; whence it is argued that some cases of it in existence without any apparent reason may be due to survival, and are now altogether useless to the animals in which they occur. The alleged protective resemblance of fishes to their surroundings is, the author suggests, not the true explanation of their colouring, their extraordinary fecundity being, in his opinion, sufficient to override the necessity for any such protection. We shall await with interest further instalments of this communication.

IN the August number of the *Zoologist* a discussion is being raised as to the manner in which the helpless and shapeless new-born young of the kangaroo is transferred to the materna pouch and affixed to the nipple from which it is to derive nutriment. Some have said that it is carried in the paws of its female parent, while one asserts that the transference takes place by the aid of the lips, and that it has been actually witnessed in the Zoological Gardens. This, however, we gather from Mr. E. Bartlett's communication, is not the case. It ought to be possible to decide the point by actual observation in a menagerie.

THAT the Edinburgh Geological Society, under the presidency of Mr. John Horne, is in a flourishing condition is manifest from the record of its *Transactions*, of which we have lately received Part 4 of vol. vii. for 1899. Mr. J. G. Goodchild contributes a short and appreciative memoir of the late Prof. Heddle, with a portrait of that distinguished mineralogist. This article is followed by a short paper, which was read before the Society in 1856, by Heddle, and not previously printed; it deals with the minerals of the Storr, near Portree. There is a useful paper on the subdivisions of the Carboniferous series in Britain and their European equivalents, by Dr. Wheelton Hind, who shows to what extent at present he has been able to subdivide our rocks into palæontological zones. Mr. William Gunn discourses on the Lower Carboniferous rocks of England and Scotland. Mr. Herbert Kynaston contributes notes on the petrology of the Cheviot Hills; and there are various other papers of local interest. A short article by Mr. E. Greenly on the Hereford earthquake of 1896 might more appropriately have been printed in the *Transactions* of a Welsh or West of England Society, as it deals with the relations of this disturbance to geological structure in the Bangor-Anglesey region.

A REPORT on the surface geology and auriferous deposits of South-eastern Quebec has been prepared by Mr. R. Chalmers (Geol. Survey of Canada, Part J, *Ann. Rep.*, vol. x.). The author has devoted particular attention to the glacial and other superficial deposits in the St. Lawrence valley, as it is chiefly in these that gold is found in workable quantities. The primary source of the gold is traced to the crystalline schists of Pre-Cambrian or Huronian ages; schists which were invaded by diorites and other intrusive rocks, and which afterwards yielded materials to the basal Cambrian conglomerates and later deposits. In these Cambrian and Silurian rocks much gold would have been disseminated in a fine state of division. After the consolidation of these rocks, upheaval, crumpling, faulting and metamorphism would seem to have taken place; and Mr. Chalmers thinks that the gold was probably brought up in solutions and concentrated along with silica and the metallic sulphides in faults and fissures, thus forming auriferous veins. Much gold was long afterwards distributed in superficial deposits during pre-Glacial times in ancient river-beds; and these deposits and the material of old weathered surfaces of the crystalline rocks have been partially removed and redeposited time after time during the changes of Glacial and post-Glacial times.

WE have received the general report on the work carried on by the Geological Survey of India during the year ending March 31, 1899, under the direction of Mr. C. L. Griesbach. Field-work has been carried on in the Raipur district, in South Rewa, and in Western Rajputana; and after many years' intermission the geological survey of the higher ranges of the Himalayas has been resumed. Trilobites of the family *Olenidae* have been found in the Upper Haimantas slates, showing that they are probably of Upper Cambrian age. The occurrence of Ammonites (*Xenodiscus* and *Arcestes?*) is noted in the *Productus*-shales of Carboniferous age. Field-work has also been carried on in Baluchistan, where Jurassic, Cretaceous, and Tertiary strata have been mapped. In the Cretaceous system,

zones of *Gryphaea vesicularis*, *Radiolites*, *Ostrea acutirostris*, &c., are noted. Economic geology rightly received considerable attention, and the mineral Mica was selected for special study. Records are also given of the important work done in the Laboratory and in the Palæontological Department.

THE fourth edition of "Remarkable Eclipses," by Mr. W. T. Lynn, has just been published by Mr. Edward Stanford. Reference is made to the results of observations of the Indian eclipse last year, and to the eclipse which will occur on May 28, 1900. The central line of this eclipse will pass from America across Portugal, Spain and Algeria.

THE tenth annual report of the Missouri Botanical Garden has recently been published. Dr. W. Trelease, the Director of the Garden, states that the collection of plants now includes more than eight thousand species and varieties, of which all but one or two hundred are named with more or less accuracy. Among the collections specially worthy of mention are the cacti, of which 462 species are cultivated; the orchids, represented by 548 named forms; the aroids, of which there are 274 species in the collection; the ferns, including 169 species; and palms, 61 species; while of hardy trees and shrubs there are 1811 species and varieties; of hardy herbaceous plants, 2179; and of vegetables, 1016. Roughly divided, the collection includes 5000 hardy forms, and 3000 cultivated under glass. The Herbarium comprises 307,460 specimens. Two scientific papers are included in the present report: one on the grasses in the Bernhardi Herbarium in the Missouri Botanical Garden, and another on a sclerotioid disease of beech roots. There is also a biographical sketch, by Prof. C. S. Plumb, referring to the late Dr. E. Lewis Sturtevant, whose gift of his extensive and valuable library of pre-Linnean works was an event in the history of the Garden; and a list of publications issued from the Garden in 1897 and 1898.

THE additions to the Zoological Society's Gardens during the past week include a Serval (*Felis serval*) from Africa, presented by Sir R. B. Llewellyn, K.C.M.G.; a Macaque Monkey (*Macacus cynomolgus*) from India, presented by Mr. T. Mark Merriman; a Bonnet Monkey (*Macacus sinicus*) from India, presented by Mr. J. M. Skinner; a Spotted Ichneumon (*Herpestes auro-punctatus*) from Nepal, presented by Miss Jackson; a Red-faced Onakari (*Onacaria rubicunda*) from the Upper Amazons, a Red-vented Cockatoo (*Cacatua hoematuropygia*) from the Philippine Islands, deposited; two Lion Marmosets (*Midas rosalia*) from South-east Brazil, four Violet Tanagers (*Euphonia violacea*), three Blue-shouldered Tanagers (*Tanagra cyanoptera*), a Black-headed Sugar Bird (*Chlorophanes viridis*) from Brazil, a Black-necked Swan (*Cygnus nigricollis*) from Antarctic America, purchased.

## OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL OCCURRENCES IN SEPTEMBER:—

| | | |
|---|---|---|
| September 4. | 19h. | Mercury at greatest elongation (18° 2′ W.). |
| 9. | 7h. | Jupiter in conjunction with moon (♃ 4° 51′ N.). |
| 12. | 6h. | Saturn in conjunction with moon (♄ 1° 55′ N.). |
| 12. | 8h. 47m. to 9h. 26m. | Occultation of 39 Ophiuchi (mag. 6·0) by the moon. |
| 13. | 5h. 5m. to 6h. 9m. | Occultation of 1 Sagittarii (mag. 5·3) by the moon. |
| 14. | 11h. 47m. | Minimum of Algol (β Persei). |
| 15. | Mars. | Illuminated portion of disc 0·967. |
| 17. | 8h. 36m. | Minimum of Algol (β Persei). |
| 19. | 6h. 25m. | Transit (ingress) of Jupiter's Sat. III. |
| 23. | 15h. 29m. to 16h. 25m. | Occultation of $A^1$ Tauri (mag. 4·5) by the moon. |

HOLMES' COMET 1899 *d* (1892 III.).—

*Ephemeris for 12h. Greenwich Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ ″ | Br. $r^{-2}$ | Br. $(r\Delta)^{-2}$ |
|---|---|---|---|---|
| August 31 | 3 2 59·26 | +40 1 26·8 | | |
| Sept. 1 | 3 37·68 | 40 16 1·8 | 0·1851 | 0·05219 |
| 2 | 4 14 34 | 40 30 31·8 | | |
| 3 | 4 49·22 | 40 44 56·5 | | |
| 4 | 5 22·26 | 40 59 16·0 | | |
| 5 | 5 53·46 | 41 13 29 8 | 0·1833 | 0·05328 |
| 6 | 6 22·76 | 41 27 37·9 | | |
| 7 | 3 6 50 14 | +41 41 40 0 | | |

SPECTRA OF RED STARS (SECCHI'S TYPE IV.).—In the *Astrophysical Journal*, vol. x. pp. 87–112, Messrs. G. E. Hale and F. Ellerman contribute the first of a proposed series of papers describing the additional work they have done on these stars since the first investigations in January 1898. The photographs have been obtained with the Yerkes 40-inch lens, which being corrected only for the visual rays, somewhat limited the region of spectrum available, until a correcting lens was obtained. This consists of a compound lens of 32 mm. aperture, supported in the cone of rays from the 40-inch objective at a distance of about 30 cm. from the slit of the spectroscope. The introduction of this lens decreases the focal length of the objective for light of λ 4500 by about 60 mm., but at the same time it so alters the original steepness of the colour-curve that it is found possible to photograph a much larger extent of spectrum at the same time.

The spectroscope originally used has been considerably modified. The collimator lens has an aperture of 31 mm. and focus of 507 mm. Three prisms of dense flint ($\mu$ = 1·696) are available, and for most of the work it has been found best to use a short camera, aperture of lens (a photographic doublet) being 37 mm. and its focal length 271 mm.

The width of the photographed spectra is usually about 0·18 mm.; the scale of the negatives is such that

at λ 4400, 1 mm. = 18·5 tenth metres;
,, λ 5350, 1 mm. = 49·6 tenth metres.

The authors proceed to describe in minute detail their methods of measurement and reduction, introducing a very ingenious *interpolating* machine they have devised to draw the reduction curves as accurately as possible.

Several illustrations accompany the article, showing the breech-piece of the 40-inch with various spectroscopes in position, two views of the interpolating machine, and a reproduction of the spectrum of 152 Schjellerup extending from λ 4800 to λ 6300. With respect to the latter, attention is drawn to the apparent bright line at λ 5592. The authors find it is easily photographed with *four minutes*' exposure, while to obtain the continuous spectrum adjoining of equal density takes from 12 to 15 minutes. This they think is in favour of its being a true bright line. From its appearance, they think it probable that whatever substance produces this line must exist in the star's atmosphere at a level *above* that of the carbon or hydrocarbon vapour which produces the heavy absorption-bands.

PHOTOMETRY OF THE PLEIADES.—Herren G. Müller and P. Kempf, of the Potsdam Observatory, have been investigating the brightness of the component stars of the Pleiades group, and the greater part of *Astr. Nach.* (Bd. 150, Nos. 3587–8) is devoted to their communication. They begin by giving tables showing the values obtained for the magnitudes of the principal stars by previous authorities, including Lindeman, Pickering, and Pritchard, and also an analysis of these values showing the varying discrepancies between the several measures of the same star. Then follows an account of their work of determining the magnitudes of 96 stars of the group, the instrument used being a Zöllner photometer in conjunction with telescopes of varying apertures. Full details are given of the preliminary experiments made for determining the constants of the instruments, &c., using certain of the stars as standards.

THE SYSTEM OF SIRIUS.—In the *Astr. Nach.* (Bd 150, No. 3588), Herr H. J. Zwiers, of Leiden, gives a revision of his previously calculated elements for the Sirius system (*Astr. Nach.*, No. 3336), which he has been enabled to make by employing the recent measures of Messrs. Aitken and Hussey,

made at Mount Hamilton during 1898 and 1899. The elements he gives are the following:—

*System II.*

| | |
|---|---|
| $T = 1894 \cdot 0900$ | $i = 46^\circ\ 1' \cdot 9$ |
| $\mu = -7^\circ \cdot 37069$ | $\Omega = 44^\circ\ 30' \cdot 2$ (1900) |
| $P = 48 \cdot 8421$ years | $\pi - \Omega = 212^\circ\ 6' \cdot 4$ |
| $e = 0 \cdot 5875$ | |

The mean value of the distance of the companion is given as

$$a = 7'' \cdot 594.$$

CATALOGUE OF ASTRONOMICAL INSTRUMENTS.—Sir Howard Grubb has sent us a revised edition of his catalogue of astronomical instruments, observatories, &c., showing the nature of the work turned out from his workshops at Rathmines, Dublin. The quality and performance of these are well known to practical astronomers, the catalogue in its new form will be interesting to all from the beautiful illustrations with which it is furnished, showing in a most convincing manner the capabilities of various optical and mechanical contrivances. The frontispiece is a reproduction of a photograph of $\eta$ Argus taken with the astrographic telescope at the Cape Observatory. At the end of the volume there are four plates showing "The solar eclipse of 1898," "A specimen of work done by a photographic doublet of 15 inches aperture," "The great nebula in Orion," and "The Dumb-bell nebula in Vulpecula"; the two latter being from negatives taken by Mr. W. E. Wilson with a reflector of 24 inches aperture.

## THE CAPE OBSERVATORY.

THE annual report of Her Majesty's Astronomer at the Royal Observatory, Cape of Good Hope, for the year 1898, has recently been published. The following is a short *résumé* of the chief details:—

*The McClean Telescope.*—The equatorial mounting of this instrument, the generous gift of Mr. F. McClean, F.R.S., reached Table Bay in good order on April 11, 1898. In six weeks all the parts had been mounted and adjusted, the stand, however, requiring considerable modification. The fittings for electrical illumination of the circles, scales, and micrometers had to be made or remodelled at the Cape.

The hydraulic motor for rotating the dome arrived on July 4, the hydraulic ram and valves for automatic clock-winding on October 11, and by November 1 all the essentials of the observatory and stand were fitted and in good working order. The raising and lowering of the floor and rotation of the dome are commanded by cords which may be actuated by the observer at the eye-end of the telescope with the utmost ease and delicacy, while the hydraulic clock-winding gear, contrived by Mr. McClean, automatically winds up the clock-weight at short intervals without communicating the slightest vibration to the telescope.

The 18-inch visual object-glass has proved to be a very fine one, both its spherical and chromatic corrections being practically perfect, as far as the kinds of flint and crown glass at present procurable in discs of that size will allow.

The 24-inch glass has two faults: the marginal images show well-marked *coma*, and the minimum focus, instead of being near to or more refrangible than $H\gamma$, is for rays of refrangibility between $H\beta$ and $H\gamma$. It is understood that Sir Howard Grubb will remedy these defects. The slit spectroscope for line of sight work, made by the Cambridge Scientific Instrument Company, was shipped from London on December 21, and the 24-inch glass cannot be returned for alteration until tests have been made with this spectroscope in conjunction with it.

*The New Transit Circle.*—The foundations for the new transit circle have been built, and the observatory, of sheet steel, is constantly expected from Messrs. T. Cooke and Sons, of York. Messrs. Troughton and Simms reported that the transit circle itself would probably be ready in March 1899.

*Astronomical Observations.*—The work of the *transit circle* has been chiefly devoted to observations of standard stars for reduction of the measures of the "Catalogue Photographic Plates." During the year 10,355 meridian transits and 9863 determinations of zenith distance have been recorded.

With the *Heliometer* systematic observations of the major exterior planets have been made, the year's work including fifty-three measures of Jupiter, forty-four of Saturn, forty-five of Uranus, and seventy-two of Neptune, all during opposition. This instrument has also been employed in the triangulation of twenty-one stars surrounding the South Pole, and for investigation the possibility, first suggested by Dr. Rambaut, of atmospheric chromatic dispersion affecting the accuracy of heliometer observations. The *seven-inch equatorial* has been employed for observations of occultations, revision of star-lists, and Coddington's comet; and the *six-inch telescope*, in conjunction with a Zöllner photometer, for the comparison of photographic and visual magnitudes in areas near the pole and equator of the Milky Way.

With the astrographic telescope, 469 plates have been obtained, 200 of these being "revision plates," as it is proposed to repeat the whole series of catalogue plates, in order to bring the epoch at which the plates were taken nearer to that at which the comparison stars were observed on the meridian.

*Geodetic Survey of South Africa.*—The field operations in connection with the geodetic survey of Rhodesia were resumed in May at the close of the rainy season, the early part of the year having been spent in training the observers in the use of the Jäderin base-measuring apparatus, the constants of which were accurately compared with the Cape measuring bars. The difference of longitude between Buluwayo and the Cape Observatory was determined by exchange of telegraphic signals on four nights, the astronomical latitude and azimuth being also observed. After the selection of a site, a base line of $11\frac{3}{4}$ miles in length was measured, and during the year seventeen stations were occupied and measurements taken therefrom.

An arrangement for the delimitation of the Anglo-German boundary between British Bechuanaland and German South-west Africa having been approved by both Governments on January 1, Lieutenant Wettstein and Major Laffan, R.E., after some months' sojourn at the observatory for practice in astronomical observations, commenced operations at Reitfontein (long. 20° E., lat. 26° 47′ S.) on November 19, by determinations of astronomical latitude and azimuth and the selection of stations.

The existing triangulation in the Cape Colony on the meridian of 20° E. long. is at present limited to the northern triangles of Sir Thomas Maclear's arc and to Bosman's accurate triangulation of Bechuanaland from Vryburg to the 20th meridian, and along that meridian from the Orange River to Reitfontein. There thus remains to complete the chain from Cape Agulhas (the southern point of Africa) to Reitfontein, a distance of only 140 miles to be filled in. The triangles for this work have been selected, and are about to be measured with the Repsold theodolite by Mr. Alston.

In connection with the survey of Rhodesia, Mr. Rhodes has promised that when he is in a position to commence the extension of the railway from Buluwayo to the Zambesi, he will place at the disposal of Her Majesty's Astronomer the funds necessary to carry on the arc of meridian from Southern Rhodesia to Lake Tanganyika. Thus there is in prospect the completion of the following valuable geodetic data:—

(1) A geodetic arc along the meridian of 20° E. long. from Cape Agulhas (lat. 34° 49′ S.) to the parallel of 22° S. lat., perhaps to 18° S. lat., *i.e.* an arc of 12° 49′, or possibly of 16° 49′ in length.

(2) An arc along the meridian of 30° E. long. from the south of Rhodesia (lat. 22° S.) to the southern extremity of Lake Tanganyika (lat. 8° 40′ S.), an arc of 13° 33′ in length. Both of these important operations will be under the direction of Her Majesty's Astronomer.

It is also hoped that the German Government will carry the latter work along the eastern border of Lake Tanganyika to Uganda, whence the way is now clear for a triangulation along the Nile to Alexandria, *i.e.* practically along the same meridian as above, 30° E. long. This latter work should for various reasons be commenced at its northern extremity.

*Longitude of Lake Nyassa.*—The longitude of Nkata Bay

on Lake Nyassa was determined by exchanges of signals between this station and the Observatory, made by Captain Close, R.E., and Dr. E. Kohlschutter. The adopted value for the longitude of the station occupied (which was 5·2s. west of the Bay) was

2h. 17m. 7·6s. E.,

and thus the previously accepted longitude was about six miles in error. This work was undertaken in connection with the delimitation of the Anglo-German boundary between Lakes Nyassa and Tanganyika.

*Longitude of Umtali.*—Similar operations undertaken by Captain Watherstone, R.E., in connection with the Anglo-Portuguese Barué Delimitation Commission, gave the longitude of Umtali as 2h. 10m. 41·2s. E.

*Time Service.*—The usual distribution of time signals for commercial and navigation purposes has been carried out.

## PROF. F. OMORI ON EARTHQUAKE-MOTION.

THREE important memoirs have recently been published by Dr. F. Omori, Professor of Seismology at the Imperial University of Tokio.[1] In the first he describes a form of horizontal pendulum adapted for mechanical registration, a method which, like the Italian seismologists, he prefers on account of its cheapness and the more open diagrams which it provides. The pendulum consists of a thin brass cylinder, filled with lead, and weighing about 14 kg. This is attached to a horizontal tubular strut of iron, which ends in a sharp conical steel point, working in a conical steel socket fixed to the wall of an earthquake-proof house. A fine steel wire connects the heavy-bob with a triangular steel prism, whose knife-edge works in a steel V-groove mounted on a projection from the upper part of the wall. The vertical distance between the points of suspension and support is 2½ metres, the horizontal distance being, as usual, very small. The length of the strut from its pivot to the axis of the cylinder is one metre. The complete period of vibration is at present 28 seconds in one pendulum, and 17 seconds in the other. The record is made by a light pointer, connected at one end with the cylinder and turning about a vertical axis working in a stirrup rigidly connected with the ground. At the end of the long arm is hinged a light triangular writing index, the point of which rests on smoked smooth paper, which is wrapped round a light wooden drum, 942 mm. in circumference, and revolving once an hour. While the Italian seismologists endeavour, as a rule, to render their instruments sensitive by using a heavy steady mass, Prof. Omori attains the same end by reducing the friction between the parts of the machine; for instance, the pressure of the writing index on the smoked paper is only ⅝ mgm. Prof. Omori also describes a portable form of the pendulum, in which the dimensions and heavy mass are smaller, and the points of suspension and support are connected with a cast-iron stand. The paper is illustrated by some interesting typical diagrams given by the pendulums of pulsatory oscillations and earthquake disturbances of neighbouring and distant origin.

It is well known that most earthquakes begin with a preliminary tremor, consisting of vibrations whose amplitude is very small and whose period is generally very short. When the origin of the earthquake is distant, the duration of the tremors, as noticed by Prof. Milne and others, increases with the distance of the observing station; and a similar relation, as Prof Omori points out in his second paper, is evident from an examination of different seismograms obtained in Japan. He shows that the duration of the preliminary tremor does not depend on the magnitude of the disturbed area of the earthquake, for no difference of this kind is to be seen between the disastrous Mino-Owari earthquake of 1891 and its five strongest after-shocks. He finds, moreover, that, for great earthquakes originating at distances between 100 and 1000 km., the duration increases by 15 seconds for every increase of 100 km. in the distance from the origin. The duration of the tremor being ascertained at two or more stations, it is thus possible to determine the position of the epicentre; and, in two cases which are given the results agree closely with those obtained from isoseismal lines. Prof. Omori remarks that the approximate variation of the duration of the early tremors with the distance from the origin can be explained by assuming the existence of two sets of waves, which, starting simultaneously, are propagated with different velocities. The mean velocities for the Mino-Owari earthquake of 1891 and the Hokkaido earthquake of 1894 are 2·2 km. per sec. for the preliminary tremors and 1·7 km. per sec. for the principal waves.

The third paper, written in conjunction with Mr. K. Hirata, is a valuable discussion of the earthquake measurements made at Miyako from June 1896 to June 1898. The observatory, which contains a Gray-Milne seismograph, is situated on a small promontory of palæozoic rocks (in lat. 39° 38′ N. and long. 141° 59′ E.), and the records may therefore be regarded as good illustrations of earthquake measurements in a rocky district. Of the twenty-five earthquakes which form the principal subjects of the discussion, six originated in the mountainous regions to the west, and the remaining nineteen under the Pacific Ocean, the point one degree east of Miyako being the most active centre of the earthquakes which disturb the eastern part of Northern Japan. The authors arrive at the following important conclusions. As a general rule, the duration of an earthquake seems to vary directly as the magnitude of the disturbed area and inversely as the distance of the observing station from the origin. The average duration of the vertical component is about four-fifths that of the horizontal component. The period of the maximum movement, both horizontal and vertical, ranges between 0·53 and 1·7 seconds for slow undulations, and between 0·12 and 0·15 second for ripples. The average period of the horizontal slow undulations is approximately constant in the principal and end portions of an earthquake, while that of the ripples is slightly greater during the principal portion than during the preliminary tremors and end portion. It is remarkable that the average period of ripples is roughly constant in all the earthquakes here considered, never varying much from one-tenth of a second. The range of the vertical motion was invariably less than that of the corresponding horizontal motion, the maximum vertical motion being on an average one-fifth of the maximum horizontal motion; and this is true both for ripples and slow undulations. The direction of the maximum earthquake movement, as a rule, is coincident with the direction of the line joining the observing station to the centre. In two earthquakes (those of February 7 and April 30, 1897), the angle of emergence can be ascertained as well as the position of the epicentre, and from these data the focal depths are found to be 15 and 9 km. respectively.

[1] (1) "Horizontal pendulums for registering mechanically earthquakes and other earth movements": *Journ. Coll. Sci., Imp. Univ., Tokio*, vol. xi. 1899, pp. 121–145; (2) "Note on the preliminary tremor of earthquake-motion": *ibid.*, pp. 147–159; (3) "Earthquake measurement at Miyako": *ibid.*, pp. 161–195.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE

MR. A. W. BRIGHTMORE has been appointed professor of engineering construction and surveying at the Royal Indian Engineering College, Cooper's Hill.

ALL particulars referring to the technological examinations conducted by the City and Guilds of London Institute, and the regulations for the registration and inspection of classes in technology and manual training, will be found in the official "Programme" just published by Messrs. Whittaker and Co. The syllabuses of the seventy different subjects, with the list of works of reference in each, and the examination papers set this year, should prove of service both to teachers and students of technology.

THE ninth summer meeting of University Extension Students in Oxford terminated on Wednesday, August 24. The meeting was throughout uniformly successful. It was divided, as usual, into two parts, the first part terminating on August 9. The number of visitors to the meeting amounted to about 1000. Of these considerably over 100 came from Germany and the United States, other nationalities being fairly well represented. The historical period selected for study was the nineteenth century from 1837, and the scientific section of the meeting was therefore necessarily occupied with the more important results obtained during that period. The lectures were well attended and excited considerable interest. In Part I., Prof. Gotch gave two lectures on "The physiology of sensation," Mr. G. C. Bourne two on "The growth of the living organism," and Prof. H. A.

Miers one on "The growth of a crystal." Mr. H. N. Dickson lectured on the "Influence of climate," and Prof. W. J. Sollas on the "Geology of Oxford." In Part II., considerably more attention was devoted to scientific subjects. Prof. W. J. Sollas conducted a series of geological classes and excursions, and Mr. A. W. Brown gave a course of practical instruction in illustration of Mr. G. C. Bourne's lectures in Part I. Dr. Farrar gave two lectures on "Prehistoric man." Two of the evening lectures were devoted to science, Dr. A. Ransome, F.R.S., discussing microbes and disease, and Mr. G. J. Burch "Wireless telegraphy." Both lectures were admirably illustrated.

THE following important announcement is inserted in the new Directory (1899) of the Department of Science and Art:—"The Lords of the Committee of Council on Education have under consideration the assessment of the efficiency of instruction in the elementary stage of science and art subjects by inspection only. It is proposed to discontinue examinations, as a test for the purposes of assessing the grant in that stage, after the year 1900. It is proposed that papers shall continue to be set in that stage for students who may desire to be examined and to possess a certificate of having passed the examination; but that in those cases a fee should be charged to cover the cost of examination." The Directory contains a number of new regulations affecting schools and classes connected with the Department of Science and Art. The object of most of the changes is evidently to encourage practical instruction in science. Visits of students to galleries, museums, and other public institutions, or attendance at field classes, may now be registered as attendances for grants. Theoretical mechanics and Section I. of the elementary stage of physiography have been added to the list of subjects in which grants for practical work may be given. The syllabuses of inorganic chemistry (theoretical) elementary stage and of theoretical and practical metallurgy have been revised, and slight modifications have been made in connection with the syllabuses of mathematics (Stage I.) and botany. With regard to schools of science, students under twelve years of age are to be excluded from them unless specially allowed by the inspector, and students at such schools are not as a rule to be admitted to the science and art examinations. Suggested laboratory arrangements for practical work in physics and biological subjects are described in the Directory, and should be of service in connection with the construction of small laboratories.

## *SCIENTIFIC SERIAL.*

THE second part of the *Zeitschrift für Wissenschaftliche Zoologie* for 1899 contains two important contributions to the morphology of Invertebrates. The first, by Dr. P. Obst, discusses the fate of the nucleolus in the development of the ovum of certain Molluscs and Arachnids; while the second, by Dr. E. Zander, deals with the abdominal bristle-like apparatus of the Hymenoptera. Especial interest attaches to the latter communication from the author's discovery that the first formation of the abdominal appendages and of the accessory sexual organs (gonapophyses) belongs to two distinct periods of development. The first of these are truly embryological, making their appearance during ovular development, whereas the second do not commence till an early larval stage is attained.

## *SOCIETIES AND ACADEMIES.*

### PARIS.

**Academy of Sciences**, August 21.—M. Maurice Lévy in the chair.—The Perpetual Secretary announced to the Academy the loss it had sustained by the deaths of MM. Frankland and Bunsen, Foreign Associates of the Academy.—On the cause of the persistent luminous trains which accompany certain shooting stars, by M. Ch. André. Remarks on an observation by MM. Lagrula and Luizet of one of the Perseids seen on August 12; the luminous streak of the meteor could be seen for twenty minutes, during which time marked changes of form were obvious in the trail of the meteor.—On an infinite continuous group of transformation of contact between right lines and spheres, by M. E. O. Lovett.—A method for determining the Newtonian constant, by M. G. K. Burgess. The Cavendish method is modified by supporting the weight carried by the torsion thread in a bath of mercury. In this way it was possible to suspend a mass of lead of two kilograms each on a torsion wire of bronze or platinum of 0·05 mm. diameter. The sensibility of this apparatus is very great, a shifting of the large masses (10 kgr. each) through 40° turning the torsion system through about 12°. The chief difficulties would appear to be the necessity of keeping the temperature of the mercury absolutely constant, and the variations introduced by fluctuations in the surface-tension of the mercury.—On the magnetic properties of iron at low temperatures, by M. Georges Claude. The hysteresis and permeability of iron are both practically constant over the temperature-range, +25° C. to −185° C., the permeability at −185° C. being only 2·5 per cent. less than at 25° C. These results are in agreement with the experiments of Thiessen, carried out at temperatures of −80°, but are in opposition to the results of Dewar and Fleming.—Decomposition of phosphate of manganese by water at 0° and 100° C., by M. Georges Viard.—On the persistence of the cardiac contractions in the phenomena of regression in the Tunicates, by M. Antoine Pizon.—On temperature and its variations in free air, from observations in ninety captive balloons, by M. L. Teisserenc de Bort. The temperature at different heights presents in the course of the year variations much more considerable than had been supposed from the observations made in an ordinary balloon. Even as high as 10,000 metres there is a marked tendency to an annual variation of temperature.

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THURSDAY, SEPTEMBER 7, 1899.

## THE LITTLE NEGROES OF THE EAST.

*The Negritos: the Distribution of the Negritos in the Philippine Islands and Elsewhere.* By A. B. Meyer. Pp. 92. (Dresden: Stengel and Co.)

DR. A. B. MEYER, the distinguished Director of the Royal Zoological, Anthropological and Ethnographical Museum at Dresden, has issued as a separate volume a translation of two chapters, brought up to date, of his sumptuous folio monograph "Die Philippinen: II. Negritos" (1893). The Negritos of the Philippines are a dwarf,[1] frizzly-haired people with a black or dull copper-coloured skin. The head is on the lower limit of brachycephaly (average index about 80). The forehead is retreating, the concave nose is broad and flat, the projecting jaw is provided with thick lips and prominent teeth. The slender body is almost entirely smooth. They are a happy, lively people to whom care seems a stranger, their greatest anxiety being the procuring of food, which consists of all things edible—fruits, roots, honey, snakes, &c. When they have provided for their wants they care for no further exertion, and love to lie in laziness and ease. Their intelligence is stated to be of a low type, and they are not able to count above five. Their songs consist of monotonous, endless unison chants. Tattooing is apparently universal, the patterns being quite simple. They are without exception monogamists.

There is no doubt that these interesting little people, about whom much more information is greatly needed, are closely allied to the pygmy blacks of the Malay Peninsula and to those of the Andaman Islands. They represent an ancient race of mankind, and thus it is important to trace their present and past geographical distribution. The name of "Aëta," "Aita," "Ita," &c., generally applied to these people, is derived from the Tagal adjective *ita*, *itim* "black" (Malay, *itam*); they were known to the Chinese under the name of "Hai-tan" at the beginning of the thirteenth century.

The headquarters of the Negritos are the island of Luzon and the small islands in its immediate vicinity; here many have crossed with the Tagals, and constitute a half-bred population called Dumagates. There can be little doubt that they are the true aborigines of the Philippines. It may be taken as certain that Negritos are found, not only in Luzon, but also in Panay, Negros, Cebu, North-east Mindanao, and Palawan, not to mention smaller neighbouring islands. It is questionable whether they occur in Guimaras, Bohol, Samar, Mindoro, and the Calamianes.

There has been much speculation on slender data concerning the distribution of the Eastern pygmy negros, of which, as we have seen, the Semangs and allied tribes of the Malay Peninsula, the Andamanese and the Aëtas form distinct groups. De Quatrefages, for example, held that traces of Negritos are found nearly everywhere from India to Japan and New Guinea, and that Negritos and Papuans live together in New Guinea, crossed and intermixed ("Négrito-Papous"), differing from the true Papuans. Dr. Meyer submits these assertions to a careful criticism, which is a valuable corrective to specious generalisation.

Theoretically, one would expect to find Negritos in Borneo; the only evidence is the account of a similar people given by Captain Brownrigg to Mr. Earl in 1845 of his shipwreck during the previous year on the east coast of Borneo, and a decorated skull described by de Quatrefages and Hamy in "Crania Ethnica." The district visited by the Captain has not been properly explored, and till that is done the question must remain in abeyance. No other white man has seen a Negrito in Borneo, and it is certain that none have been heard of in Sarawak; Mr. Charles Hose, who probably knows more about the natives of the interior than any one else, disbelieves in their existence. I have myself seen low-caste natives in the interior of the Baram district of Sarawak, whose hair was wavy and almost curly; the contrast between these and their nearly straight-haired companions could easily lead to exaggeration, but this does not necessarily indicate Negrito blood. Dr. Meyer discusses the *provenance* of the decorated skulls from Borneo in European museums; at present our information is too meagre for accurate generalisation. There appears to be no evidence that the skull in question came from the "interior of Borneo," and it is by no means incredible that the skull, or the person when alive, was imported into Borneo; slaves have probably been imported at different times, and we know that various peoples have migrated into Borneo from all quarters.

There is no evidence of Negritos in Celebes, Timor, the Moluccas and Lesser Sunda Islands. The same applies to Java (the Kalangs are not Negritos); but in Sumatra and the neighbouring islands there is still some doubt whether such a population once existed. There is less evidence for an early Negrito stock in Formosa, Japan and China. The evidence for the Mergui Archipelago is doubtful, and that for the Nicobar Islands is more so. More evidence is required for Annam, Cochin China, and Cambodia.

A good deal has been written about the occurrence of a short, dark, frizzly-haired people in India, but of these there is no evidence whatever. Curly hair is characteristic of the "Dravidian" peoples, but this is never woolly. Prof. Keane figures[1] a "Panyan woman" as a "Negrito type, India"; but a reference to the original photograph published by Thurston[2] will prove that the hair is distinctly curly, which feature is unfortunately lost in Keane's reproduction. Thurston[3] gives the average height of twenty-five Paniyan men as 1·574 m. (5 feet 2 inches), with a cephalic index of 74; these are not Negritos.

The affinities of the Australians, more or less, with the "Dravidians" is now generally accepted, but a Negrito element has not yet been proved for them. Some hold that the Tasmanians belonged to that stock, and in his

[1] Average height for males 1442 mm., 4 ft. 8¾ in.; for females 1385 mm., 4 ft. 6½ in.

[1] "Man Past and Present," 1899, Pl. II. Fig. 3.
[2] *Bulletin* Madras Govt. Mus., 1897, ii. Pl. X.
[3] *Loc. cit.*, p. 29.

recent presidential address to Section F of the Australasian Association for the Advancement of Science, "On the Origin of the Aborigines of Tasmania and Australia," Mr. A. W. Howitt believes that

"the Tasmanians were the autochthonous inhabitants of Australia, and that their preservation in Tasmania was due to isolation by the formation of Bass Strait. The occupation of the continent by the Australians who, it may be reasonably held, were in a higher state of culture, must have resulted in the amalgamation of the two races, or by the extirpation of the former inhabitants, so far at least as regards the males."

He also suggests that a later wave of Papuan migration was virtually stopped by Torres Straits. He also puts forward

"the following tentative hypothesis: An original Negrito population, as represented by the wild tribes of Malaysia; a subsequent offshoot represented by the Andamanese and Tasmanians, and another offshoot in a higher state of culture originating the Melanesians."

Whatever Mr. Howitt writes is worthy of the careful attention of anthropologists, and it would be well to direct future research with this hypothesis well in view. As Garson, Ling Roth and others have expressed the opinion that the Tasmanians were of Negrito origin (using that term in a general sense), it is rather a pity that Dr. Meyer has not discussed this point.

Finally Meyer discusses the relationship of the Negritos to the natives of New Guinea; he, with Micluko-Maclay, asserts the unity of origin of the Negritos and Papuans, and at the same time insists that the Papuans are diversified and show various types.

"Does it point to a crossing of different elements, or does it simply reveal the variability of the race? I [Meyer] incline to the latter assumption as the simplest and as provisionally sufficient, particularly as in the still so limited state of our knowledge it will be labour lost to try to resolve a race like the Papuan into its various elements."

This is not the place to enter into a discussion on this difficult problem; for the present I can only say that I am inclined to adopt the former view. I certainly have not seen or heard of any trace of Negritos as such, the brachycephals I encountered in New Guinea were no shorter than the dolichocephals, nor had they more Negritic affinities than the latter. Meyer makes the following emphatic statement:

"A Negritic race side by side with the Papuan race nobody has been able to discover, just because it does not exist, and it does not exist because the Papuan race, in spite of its variability, is on the one hand a uniform race, and on the other as good as identical with the Negritos."

A careful perusal of Dr. Meyer's critical study leaves one fact strongly imprinted on the mind, and that is the urgent need for further evidence. There can be no doubt that observation in the field is by far the most important branch of anthropological work at the present time, and all our energies should be employed in this direction. The time is fast approaching when it will be too late.

A. C. HADDON.

## BACTERIA.

*Bacteria; especially as they are related to the Economy of Nature, to Industrial Processes, and to the Public Health.* By George Newman, M.D., F.R.S. (Edin.), D.P.H. (Camb.), &c. Pp. xvi + 351. (London: John Murray, 1899.)

THE author in his preface says that the book is "an attempt, in response to the editor (F. E. Beddard, F.R.S.) of the series (the Progressive Science Series), to set forth a popular statement of our present knowledge of bacteria." "Popular science," continues the author, "is a somewhat dangerous quantity with which to deal. On the one hand it may become too popular, on the other too technical. It is difficult to escape the Scylla and Charybdis in such a voyage."

It may be said at the outset that Dr. Newman has accomplished a very difficult task in a manner which does him credit. Nevertheless, it is to be hoped that in future editions the writer will judiciously curtail certain sections and expand others, and will exercise more caution in laying down doctrines which, in some cases, might mislead the lay reader, and which occasionally even show a wrong conception of the present state of our bacteriological knowledge. That a further edition will be called for at no distant date need hardly be doubted, considering the general excellence of the work.

The first thirty-eight pages deal with the biology of bacteria. This portion of the book might well be curtailed; it contains little information that is new, and much that is old and contained in every text-book of bacteriology.

The second chapter deals with the bacteria in water, and includes much valuable information. It contains a useful reference to *B. enteritidis sporogenes* (Klein), a virulent anærobe apparently causally related to diarrhœa. The biological treatment of sewage might usefully have been discussed more fully and in a separate chapter. The statement, "The cultivation beds also have an inimical effect upon infective bacteria. Hence the final effluent is practically germ-free as regards pathogenic organisms," must be accepted with caution.

The chapter on bacteria in the air is well and concisely written, but the author quotes an experiment of his own which is a little difficult of comprehension. To quote his own words:

"The writer recently obtained some virulent typhoid excrement, and placed it in a shallow glass vessel under a bell-jar, with similar vessels of sterilised milk and of water, all at blood heat. So long as the excrement remained moist, even though it soon lost its more or less fluid consistence, the milk and water remained uninfected. But when the excrement was completely dried it required but a few hours to reveal typhoid bacilli in the more absorptive fluid, milk, and at a later stage the water also showed clear signs of pollution."

Shattock's interesting experiments are quoted, showing that sewer air does not necessarily exalt the virulence of a strain of lowly virulent diphtheria bacilli. It is to be noted that this does not affect the question of the possibility of sewer air depressing the vitality of the individual, and so allowing lowly virulent bacilli, either already present in the throat or subsequently gaining entrance, to develop and display their full power of pathogenicity.

The chapter on fermentation is a good one and is

more in touch with the original scope of the work as outlined by Dr. Newman himself in the preface. Moreover, there is much that is suggestive to the mind of the bacteriologist seeking for new avenues of research in a most important and imperfectly explored field.

The subject of bacteria in the soil is well dealt with in Chapter v., and the author records some of his own interesting experiments on nitrogen-fixing bacteria.

Chapters vi., vii. and viii. treat respectively of bacteria in milk, milk products and other foods; the question of immunity and antitoxins; and bacteria and disease. There is much in these chapters which will repay careful perusal. Dr. Newman very properly draws attention to Dr. D. S. Davies' persevering and instructive investigation of the late epidemic of typhoid fever at Bristol. It is a little difficult to measure the author's meaning when he says:

"Though the typhoid bacillus appears not to have the power of multiplying in milk, it has the faculty of existing and thriving in milk."

Dr. Newman states that the cause of scarlet fever is unknown. Perhaps it would be fairer to say that some bacteriologists consider that the proof that Klein's streptococcus is the causal agent rests on insufficient grounds.

The last chapter is devoted to disinfection, and the subject is well treated.

The book is rendered attractive with twenty-four good micro-photographs. There are seventy other illustrations; many of these are, as the author admits, diagrammatic. In a future edition some, at all events, of these might be usefully replaced by micro-photographs.

In conclusion, it may be said that Dr. Newman has successfully accomplished a very difficult task. It is true that the author has not altogether fulfilled his original intention of eliminating technical matters, and that exception may be taken to certain statements as being too dogmatic to please the cautious reader and thinker. Yet, judging the book as a whole, it may be said that it is certain to enhance the writer's reputation, and will surely be welcomed by the numerous readers of the publications of the Progressive Science Series. It is to be hoped that a demand for this volume may speedily call for a second edition.

A. C. HOUSTON.

## OUR BOOK SHELF.

*Leitfaden der Kartenentwurfslehre.* Von Prof. Dr. Karl Zöppritz. Second edition. By Dr. Alois Bludau. Erster Theil. *Die Projektionslehre.* Pp. x + 178. (Leipzig: Teubner, 1899.)

DR. BLUDAU, who has devoted much attention to map-projections, and has written some noteworthy papers on the subject, has lately published the first part of his new edition of the well-known work on cartography by Karl Zöppritz. The book has been thoroughly revised and recast; and the additional matter is so large as to render publication in two parts, issued separately, desirable. The first part deals only with the various projections of portions of the sphere that have from time to time been proposed. Dr. Bludau's object has been to produce a work which should meet the requirements of the present day, and be of real service to cartographers. With this view those projections which are of practical use are fully described, whilst those that may be termed "fancy" projections are only briefly discussed. Every effort has been made to ensure clearness and distinctness, and only those mathematical propositions and formulæ that are absolutely requisite are given. Dr. Bludau has successfully carried out his programme. The book is well written, and will be of great value and assistance to those who are practically engaged in the production of maps. Every important projection is mentioned with its date and the name of its author; and full use has been made of the researches of Tissot, and the published works of Profs. Fiorini of Bologna, Hammer and others. Dr. Bludau gives a list of the authorities whose writings he has consulted, and it may be noted that it does not include the name of any Englishman. The subject has been much neglected in this country, and nothing of any importance has been published since the papers of Airy and Clarke, and the well-known little book on the construction of maps by Hughes, the last edition of which appeared in 1864. Dr. Bludau gives almost without alteration the useful hints on drawing which appeared in the original "Leitfaden" of Zöppritz; and there are some tables for the construction of projections. Part ii. is to deal with topography and cartometry, and to contain a number of additional tables.

C. W. WILSON.

*The Dog, its External and Internal Organisation.* Edited by A. C. Piesse, M.R.C.V.S.; with Anatomical Description by W. S. Furneaux. With five plates and text cuts. Pp. 31. (London and Liverpool: G. Philip and Son.)

THIS is an oblong work of 28 pp. of the puzzle-book order, with five plates, the parts of which are cut out and so arranged in super-position that the reader first skins his dog and then works through its skeletal, circulatory, and muscular apparatus and viscera, until a median longitudinal section is reached. The latter is conspicuous for the delineation *in situ* of the central nervous system, but the entire peripheral system has been mysteriously overlooked.

The first 14 pp. of the text are devoted to a consideration of the history of the dog and of the leading breeds, illustrated by six woodcuts, the remaining 14 pp. to a so-called "Anatomical Description"—in reality an attempt at a general *résumé* of the anatomy and physiology of the vertebrate organism with especial reference to the dog, the whole concluding with a detailed explanation of the plates, the organs and structures represented being indicated by numbers. The work is of too thin and amateurish a character to merit detailed comment in these pages, but while fairly trustworthy so far as it goes, it is wanting in balance and accuracy of detail; and in attempting to express scientific facts in non-scientific terms the authors at times lapse into a looseness of expression apt to mislead.

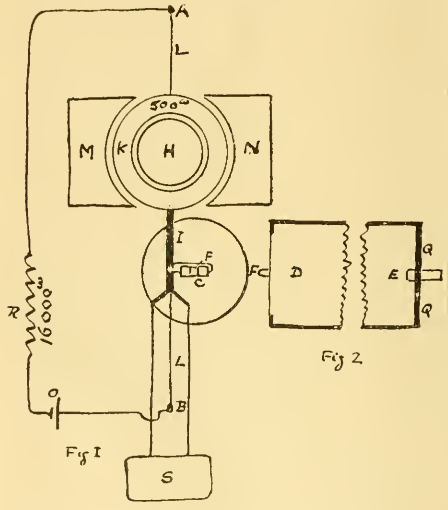
To define the "Dogs (*Canina*)" as belonging "to the family of Mammalia," and to indulge in feebly stated generalities about the structure of ganglia and the orders of nerve-fibres, to the exclusion of an adequate description of the course and nature of the leading nerve tracts, is but to confuse the mind. We do not know for what class of persons the book is intended. It will be useless to the serious student, and of little avail to the lay reader, as conveying an accurate idea of the most elementary facts. The small modicum of anatomy which it contains, interspersed with passing allusions to habit and to appearances indicative of disease, will doubtless be attractive to some persons, but by those who desire full information, such as can alone be of real service educationally or otherwise, access must be had to well-known authoritative works such as Ellenberger and Baume's "Anatomie des Hundes." The volume before us may perhaps do something to encourage a love of the dog and an appreciation of the beautiful in its construction, leading thus up to the study of the more directly useful; and for this reason we regret the more that a bibliographic list of the afore-mentioned authoritative treatises should not have been given. Without one the present work fails in its most useful purpose.

## *LETTERS TO THE EDITOR.*

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### A Hertz Wave Receiver.

DURING a visit to Adelaide in December last year, I was asked to suggest some sort of apparatus whereby Hertz wave disturbances might be observed. The result may perhaps be of some interest at the present time. The spark at the oscillator was small, as only a small induction coil was available. From previous experiments made by me, I had discovered that in order to obtain great sensitiveness the distance between the poles of a Branly detector should be as small as possible; also the amount of current employed should be very small. After many experiments, I devised an apparatus in which only about 1/16 of a milliampere gave excellent results. The apparatus was simple and easily constructed. In Fig. 1, M N are the poles of the permanent magnet of a D'Arsonval galvanometer; K, its coil having a resistance of 500 ohms; H, the internal soft iron




— Hertz wave receiver —

fixed core; L L, the flat suspension wires; I, a rod of ebonite to the side of which a minute Branly receiver is attached. This forms a part of the galvanometer circuit, and moves with the coil through its angle of displacement, the ends A B of the suspension wires being fixed to the frame (not shown). The circuit included one small dry cell, O, and a non-inductive resistance of 16,000 ohms. In order that the Branly receiver C, after being made a conductor by the influence of a Hertz wave, may be restored to its condition of high resistance, it is brought up against a point F, when deflected (a side view of this is shown in Fig. 2). This point is kept in a state of vibration by means of a jet of water, thus, D E is a tube furnished with an elastic disc, to which a projection, F, is attached; a jet is so fixed at E that its discharge impinges on the centre of the disc, the jet is fixed to the tube by a bar, Q Q, the discharge is affected by the tube as a resonator, and hence F vibrates. The suspended coil, K, is furnished with a mirror and a pointer, whereby its movements are easily seen. This form of decohering instrument was used to avoid the evil effects due to electromagnetic vibrators, which act on a receiver if very sensitive. The induction wings were connected to the apparatus at A and B. On repeating the experiment at home, I found that 1/16 milliampere is by no means the smallest current that might be used; all that is required is a current sufficient to move the suspended coil. I am informed that the current used in wireless telegraphy is usually about one milliampere; it is obvious that by increasing the sensitiveness of the galvanometer a more sensitive coherer may be used. By means of a vane, S, moving in liquid the movements of the coil are damped. The cohering substance was an 8 per cent. alloy, made in the oxyhydrogen flame, and then reduced to filings in the usual way; it was found to be exceedingly sensitive, much more so than the mechanical mixture of filings of the two metals.

I made several attempts to use a sensitive galvanometer for closing the circuit; the results were unsatisfactory, the closing of the circuit was uncertain, and when it was closed the tendency to stick, due to the contacts, was a source of much trouble. It then occurred to me that the whole difficulty would be obviated by attaching the coherer to the moving axis of the galvanometer coil itself, for by this means the contact is entirely avoided, while the coherer is brought within the range of a constantly vibrating projection which causes immediate decoherence. A vibrating reed was tried as a decoherer, but abandoned owing to the trouble of feeding it with air under pressure. Another form of decohering vibrator was also tried, which consisted of a long tube, part of which was glass; each end was furnished with a tympan, one of which was placed as F and D, Fig. 2; the other tympan was led into a metal box containing an electromagnetic vibrator, the hammer of which beat upon the tympan remote from the galvanometer. The electromagnet may thus be placed at a great distance from the apparatus, while its impulses are communicated through the column of air in the tube.

Since my return home, I have used the Wehnelt circuit breaker for producing Hertz waves with ordinary oscillators; the effects appear to be perfect, although the space at my disposal, about two miles, is for the most part covered with houses and high buildings. F. J. JERVIS-SMITH.

Oxford, August 26.

### Is Insusceptibility to Vaccine produced by Small-pox?

IF vaccination inhibits, arrests, modifies, or mitigates variola because it is one with variola, if the attenuated virus and local eruption interfere with the more virulent and generalised eruption, may not a reciprocal antagonism be expected? If the minor malady interfere with the major malady, how much more should the major malady, within a reasonable period of years, confer some degree or manner of general constitutional protection in respect of the minor, if not a modification of the local result of vaccination? If I mistake not, systematic investigation on this point, on the human subject, has been strangely neglected in England, if not elsewhere.

CHARLES G. STUART-MENTEATH.

23 Upper Bedford Place, W.C., August 14.

SMALL-POX does leave behind it an insusceptibility to vaccinia. If the writer of the letter will refer to Dr. Monckton Copeman's article on "Variola and Vaccinia, their Manifestations and Inter-relations in the Lower Animals: a Comparative Study" (*Journ. of Path. and Bact.*, vol. ii., 1894, p. 408, *et seq.*), he will find references to the protection conferred by variola against vaccinia. That systematic investigation has not been carried out is probably due to the fact that the subject has so little practical interest.

From the point of view of those interested in the general question of immunity, this subject is well worth careful and systematic study. G. SIMS WOODHEAD.

## *THE DOVER MEETING OF THE BRITISH ASSOCIATION.*

IN addition to the arrangements described previously, an installation of Marconi's system of wireless telegraphy will be set up in the Maison Dieu Hall of the Town Hall. There will be constant communication with the South Foreland, the East Goodwin Lightship and Wimereux-Boulogne. By means of this arrangement visitors will be kept fully informed of the proceedings of the French Association at Boulogne.

In Section A (Mathematics and Physics) the President's address is intended to be taken at 10 a.m. on Thursday, September 14. On Friday, September 15, papers connected with mathematical physics and electricity will be read. On Saturday, September 16, on the occasion of the French visit, it is hoped that Prof. J. J. Thompson and Prof Oliver Lodge will communicate papers. On Monday, September 18, the section will subdivide into a meteorological and a mathematical section. On Tuesday, Prof. Threlfall will exhibit and describe his gravity metre, and a discussion on platinum thermometry will be opened by Prof. Callendar and Drs. Harker and Chappuis.

The President's address in Section B (Chemistry) will be given on Thursday, September 14, immediately after the address to Section A. It will deal with the assimilation of carbon by the higher plants, and will be mainly descriptive of new work carried out during the past two years in the Jodrell Laboratory at Kew. In addition to papers of a specially technical character several discussions of interest have been arranged for the meeting. On the occasion of the visit of the French Association on the Saturday, there will be a joint meeting of Sections B and K to discuss the question of symbiotic fermentation, both in its chemical and biological aspects. This discussion will be opened by Prof. Marshall Ward; Dr. Calmette and Prof. Armstrong, amongst others, will take part in it.

Prof. Armstrong has undertaken to open a discussion on a subject of importance and interest in organic chemistry, under the title of "Laws of substitution, especially in benzenoid compounds"; whilst a prominent place in the programme will also be given to inorganic chemistry in a discussion on "Atomic Weights," to which Prof. F. W. Clarke, of Washington, will communicate a statement of his views. Amongst the special papers already promised, Prof. Dewar hopes to be able to communicate the results of his most recent investigations on the solidification of hydrogen, and the liquefaction of helium. Prof. Ladenburg, of Breslau, will read a paper on "The development of chemistry in the last fifteen years," and Mr. H. J. H. Fenton will give an account of his recent researches on "Oxidation in the presence of iron."

In Section D (Biology) the following papers of general interest to biologists will be read, amongst others: Mr. J. J. Lister will describe a remarkable new type of calcareous sponge discovered by Dr. Willey during his expedition to New Britain. Mr. J. J. Budgett, who has just returned from the River Gambia, will give an account of the zoological results of his expedition. Messrs. Gamble and Keeble will communicate an account of their experiments on the colour changes of prawns. Prof. Poulton will describe a new series of experiments on the protective value of form and colour in insects. Mr. W. Garstang will give an account of the methods and results of a periodic survey of the plankton and physical condition of the English Channel. Dr. C. G. Petersen will describe the plaice culture in the Limfjord (Denmark). Valuable communications on special morphological problems will also be submitted. Mr. Graham Kerr will discuss the origin of the paired limbs of vertebrates; and Dr. Willey the process of cephalisation in mollusca and vertebrata. In the marine excursion, if weather permits, the plankton collecting apparatus will be demonstrated; and Dr. Petersen and Mr. Garstang will exhibit their new forms of net for opening and closing under water.

In Section E (Geography) the following papers are promised: Presidential address by Sir John Murray on the floor of the ocean; Mr. J. J. Buchanan, F.R.S., on the physical and chemical work of an Antarctic expedition; Dr. H. O. Forbes, on a visit to Sokotra; Mr. A. W. Andrews, on the use of lantern slides in geographical education; Mr. O. H. Howarth, explorations in Oaxaca, Mexico; Dr. G. Schott (Homburg) on the oceanographical work of the *Valdivia* Expedition; Mr. H. N. Dickson, on the oceanography and meteorology of the North Atlantic; Mr. H. N. Dickson will also read a paper on the temperature of the sea water round the British Islands; Sir John Farquharson, on twelve years' work of the Ordnance Survey; Mr. Vaughan Cornish, on the sand dunes of Lower Egypt; Mr. George Murray, F.R.S., on the distribution of plants in the oceans; Mr. Robert Irvine, on the distribution of nitrogen in the sea; Mr. C. W. Andrews, on oceanic islands; Sir John Murray and Mr. F. Pullar, on the bathymetrical survey of the Scottish Lakes; Mr. W. R. Rickmens, on a journey in Transcaucasia; Dr. H. R. Mill, on the terminology of the forms of ocean floor; and Mr. E. Heawood on the discovery of Australia.

In Section H (Anthropology) the President will deliver his address on Thursday morning at eleven, and the remainder of the day will probably be devoted to the discussion of reports and papers on physical anthropology. The subject of finger-prints as means of identification will be examined in important papers by Dr. Francis Galton, and Mr. E. R. Henry, who has used the method with success in police work in India. Other anthropometric points will be discussed by Dr. J. G. Garson. Mr. J. Gray contributes a paper on the population of East Aberdeenshire; and Mr. D. McIver on his recent work on the early inhabitants of Egypt.

Friday will be devoted to an important series of papers and exhibits arising out of Prof. Haddon's recent expedition to Torres Straits. Communications are promised from Prof. Haddon himself, and from Dr. Seligmann and Messrs. Ray and Rivers, who took part in the expedition. Some, if not all, of the archæological papers will be taken on Saturday. Monday and Tuesday will be occupied with papers on Ethnography and kindred subjects. Wednesday will, as usual, be reserved for overflows and late arrivals.

Among the reports, that on the education of defective children deserves particular notice, and those on excavations at the lake village of Glastonbury, the Roman site at Silchester, and elsewhere in this country, will afford interesting material for comparison with those of our French visitors.

The President's address in Section K (Botany) will be delivered at 10.30 on Thursday, September 14. On Friday afternoon a lecture—of a semi-popular nature—will be delivered by Mr. Harold Wager, on sexuality of the fungi. Saturday morning will be given up to a joint discussion with Section B on fermentation, which will be opened by Prof. Marshall Ward. On Saturday afternoon the members of Section K propose to have a botanical excursion to the sand dunes between Deal and Sandwich. The contributions to be made to the Section include papers on fungi by Prof. M. Ward, Prof. Potter, Mr. Wager, Dr. Darbishire and others; on physiological botany, by Mr. Francis Darwin; on latex of india-rubber, by Mr. Biffen and Mr. Barkin. Prof. Campbell contributes a paper on studies in Araceæ; and Mr. Willis deals with the morphology and life-history of the Indo-Ceylonese Podostemaceæ. Miss Sargant promises a demonstration of vermiform nuclei in the fertilised embryo-sac of *Lilium Martagon*. Prof. Bower will read a paper dealing with the sporangia of ferns. Prof. Bertrand, of Lille, communicates a paper on *Sigillaria*. Prof. Weiss sends a contribution dealing with *Lepidophloios*, and Mr. Seward and Miss Gowan deal with the botany and geology of the maiden-hair tree. There are also other papers expected on fossil botany. Mr. Lloyd Williams will give an account of further work on the Brown Algæ. There are also to be contributions to the Section on local botany and on other subjects of general botanical interest.

## THE FORECAST OF THE MONSOON.[1]

THE brief telegrams that have lately been published from India concerning the amount of rainfall have given a very uncertain note. Favourable and unfavourable accounts have followed in rapid succession, and at the moment of writing it seems doubtful whether to expect a normal amount of precipitation, or to dread a recurrence of one of those calamitous famines, which drain so severely the resources of India, and from the last of which she has barely recovered. In these circumstances, it is of more than usual interest to turn to the official forecast, to see how the causes, which in the opinion of the best-informed meteorologists affect the climate of India, are operating for and against the prospects of a successful harvest.

At the outset we meet with a grave disappointment. The Simla authorities distinctly express their inability to make a forecast, on any scientific ground, of two very important factors which affect the agricultural value of the monsoon rainfall. These are the possibility of the occurrence of a protracted break in the rainfall during the months of July and August, even after the season has opened favourably, and of an unusually early termination of the rains in the North and Central Provinces of India and in Bengal. For fifteen years the Meteorological Office has deplored the want of the necessary data that would warrant a prediction on these important topics, and there are no signs that the information will be forthcoming at an early date. As a matter of fact, the authorities go little further than an examination of the conditions under which the south-west monsoon currents will arrive on the coasts of the peninsula. It is true that the probable amount of rainfall in the various provinces of India is considered at some length, but it is expressly declared that this "forecast is a statement of probabilities, and not of certainties, and that it is liable to error from the limitation and uncertainty of part of the data on which it is based."

Similar words accompany all the forecasts that prudent men venture to make, and it must be admitted that the continual repetition is wearisome and distressing. Such a caution may be necessary, but if it produces on the mind of an impatient public the impression that little or no advance is being made in meteorology, and particularly Indian meteorology, a great injustice is done to a body of highly-skilled observers, who have not spared themselves to benefit science, to improve the lot of the agriculturist, and to strengthen the hands of the Government in dealing with a misfortune they are eager to alleviate, but powerless to avert.

But it is not difficult to see some of the reasons that compel the staff to halt at the result of this preliminary investigation. Forecasting, as understood in England, and which practically rests on the capacity of the telegraph to outrun the storm or the weather it announces, would be valueless in India. Away from the coasts and outside shipping interests, there is no necessity for daily forecasting, nor for the study of those ephemeral fluctuations which go to make up our weather. On the other hand, the meteorological conditions that result from the movement of enormous masses of the air attract greater scientific attention, owing to their periodic character and the effect likely to be produced on agriculture and the well-being of large masses of the population. It would be wrong, however, to forget that in late years, and mainly under the energetic direction of Mr. Eliot, barometric variations, however small in amount, have been studied with good effect, and have revealed the probable existence of cyclical variations which can have considerable influence in promoting or checking the general oscillatory motion of the air across the equator, to which motion the south-west and north-east monsoon winds are mainly due.

But in the forecast before us, though the variations of pressure from the normal, and the effect such fluctuations have on the local weather existing in India immediately preceding the advance of the monsoon, are treated as a factor in the problem, two other conditions have naturally great weight. These are the amount and time of occurrence of the snowfall in the mountain districts adjacent to Northern India, and the behaviour of the south-east trades in the preceding season, as investigated at Seychelles, Mauritius, the Cape of Good Hope, and the logs of ships passing over the area affected. Such latter information is of necessity incomplete, but is likely to be of great importance in proportion as it covers a larger area, for the greater the district brought under review, the greater the probability of tracing the true physical cause on which important variations rest. It may not be out of place, as showing the wide extent over which meteorological phenomena extend themselves, and the consequent necessity for the examination of all remote causes to which they may be traced, to recall the apparent connection existing between the barometric oscillations in the Indo-Malayan region on the one hand, and Russia and Siberia on the other. Further, we have some evidence of connection between the south-east rains of South Africa and the amount of the rainfall at the time of the summer monsoon, while the overflow of the Nile seems to participate in similar periodic variations. Such general disturbance tends to point to a common cause, and it is gratifying to know that the possibility of the connection has been pointed out by the Indian meteorological officers, who are fully alive to the importance of discovering the origin of these effects, which demonstrate themselves periodically. In basing the forecast on more or less local appearances, we seem to recognise the weak point in long-period forecasting. We are in the position of a physician who deals with the symptoms rather than the origin of a disease.

This difficulty of trusting to appearances may be illustrated in many ways. For instance, how are we going to estimate the relative importance of the two operating factors we have mentioned above, the snowfall on the Himalayas and the behaviour of the south-east trades? And how are we going to act if we find the indications from the two sources discordant? Some time since we believe that the snowfall was regarded as the one important item in the making up of the forecast. Scanty rain was anticipated as the consequence of heavy snow, but greater experience has somewhat discredited the notion. Late snow in April or May, or the cause which produces the late snowfall, no doubt does exercise very considerable influence locally on the distribution of the monsoon winds; but when we have to deal (as already pointed out) with the effects produced by the circulation of an atmosphere covering an entire hemisphere, such local results play but an insignificant part. Nevertheless, we find Mr. Eliot, who doubtless is glad to avail himself of every source of information, carefully tabulating the time and amount of the snowfall from Afghanistan on the West to Assam in the East. But, in drawing his conclusion, he does not leave out of sight the local character of the indication, and a distinction is drawn between the conditions that should follow the reports from Western India and those received from the Eastern Himalayas. In the former case, the signs point to an early and strong monsoon with beneficial results to the utmost limits of the Punjab. The conclusions to be drawn from the accounts from the eastern portion are more uncertain both on account of deficiency in the data received and greater doubt in the interpretation of the sign, but it is expected that the rainfall in North-east India will be diminished,

[1] "Memorandum on the Snowfall in the Mountain Districts bordering Northern India, and the Abnormal Features of the Weather in India; with a Forecast of the S.W. Monsoon Rains of 1899." By John Eliot, Meteorological Reporter to the Government of India, and Director-General of Observatories in India. (Simla: June 1899.)

while heavier rain will be prevalent in the north-west. It will be interesting to compare this prediction with actual results; but at present we are more concerned to point out the care that is taken in preparing the forecast, the difficulty in the collection of exact data, and the manful determination to make the best use of all available sources.

This scrupulous care is well illustrated in the second class of information incorporated into the weather prediction, and which rests on the abnormal features of the recent meteorology of India. To discuss these with any prospect of success, it is first necessary to determine correct normals. The work that this involves can only be appreciated by those who have been actually concerned in a similar inquiry, but it is a method of investigation into which Mr. Eliot and his predecessor, Mr. Blandford, have thrown themselves with signal success. The volumes of the Indian Meteorological Memoirs bear witness to the ability and zeal with which the work has been carried on throughout some twenty-five selected observatories. We may well express the hope that so much work is now yielding abundant fruit.

## THE PRESENT POSITION OF THE INVESTIGATION OF THE MALARIAL PARASITE.

THE *rôle* played by the mosquito as a carrying agent of the malarial parasite from man to man seems to be restricted to one genus, the Anopheles. Major Ross, of the Liverpool School of Tropical Diseases, in a telegram from Sierra Leone, announces the fact that he has found the Anopheles there, and that it may be the intermediary host of the quartan malarial fever.

Many observers in different countries, noticing the fact that malaria is most prevalent at the most active period of mosquito life, have attributed malaria to the agency of this insect. Dr. Patrick Manson, in 1894, first brought the subject forward in England, and, acting on his suggestion and advice, Major Ross undertook an investigation in India.

In 1897, by using two species of Anopheles, Ross traced the malarial parasite into the wall of the stomach of the mosquito after it had fed on patients whose blood contained the crescentic gametocytes; the next year he succeeded in tracing the complete life-history of the proteosoma *Grassii Labbé* of sparrows, and showed that its intermediary host was one particular kind of mosquito, the *Culex pipiens*. The gametocytes contained in the red blood corpuscles of the vertebrate host pass with the blood into the stomach of the mosquito, and passing through the stomach-wall bulge into the body-cavity; here a sexual process takes place, zygotoblasts are eventually formed, which pass into the insects' blood, and finally find their way into the salivary gland and to the duct leading from this to the extremity of the stylet; from here they escape into the blood of the vertebrate host when the insect bites. A full account of the process is given by Ross in NATURE of August 3.

Following on these results, Grassi in Italy attacked the problem from another point of view; he studied the mosquitoes prevalent in the different parts of the country where malaria occurs. The results were interesting. He found there was no indigenous malaria where the *Culex pipiens* was common, but it did occur where the large mosquito Anopheles was found.

Bignami and Bastianelli, who had been trying unsuccessfully to infect a man by allowing mosquitoes to bite him, attributing their want of success to the use of the wrong kind of mosquito, and, acting on the observations of Grassi, tried again with some mosquitoes imported from a malarious district. This time they succeeded in infecting the man with malaria of the same type that prevailed in the district from which the mosquitoes came. Moreover, they have shown that the development of the human form of parasite in the body of Anopheles is identical with the development of the proteosoma of birds in *Culex pipiens*, as observed by Ross.

According to these observers, the species *Anopheles claviger* is the most common intermediary host of the parasite of malaria in Italy, the tertian and summer-autumn types.

It is evident that the next step in the study of malaria should be to hunt for the different species of Anopheles and see if these are the intermediary hosts of the different types of malaria throughout the world, and what particular species is most concerned in transferring the parasite from man to man. Grassi has done this for Italy, and now we hear that Ross has found a species of Anopheles to be concerned in the transference of quartan fever; thus all the types of malarial fever are now referred to the Anopheles as their intermediary host. His full report on return from Africa will be read with interest.

Whether the Anopheles can be extirpated from a locality, and by what means, will be the problem for scientific workers resident abroad to settle; fortunately they seem to be confined to small areas, so the suggestion of Ross to draw off the water from stagnant pools may not be so hopeless a task as it would at first appear.

## NOTES.

THE following men of science have been elected fellows of the Reale Accademia dei Lincei. As ordinary fellows: for mathematics, P. Tardy, G. Veronese; for mechanical science, G. Favero, G. Colombo, V. Volterra; for agricultural science, A. Targioni-Tozzetti. As corresponding fellows: for mathematics, G. Ricci; for mechanics, G. A. Maggi; for physics, G. Grassi, A. Battelli; for crystallography and mineralogy, A. D'Achiardi; for botany, F. Delpino; for agriculture, A. Borzì; for pathology, E. Marchiafava. As foreign fellows: for mathematics, G. Mittag-Leffler, J. Weingarten; for physics, E. Mascart, W. Kohlrausch; for chemistry, Ludwig Mond, E. Fischer; for crystallography and mineralogy, C. Klein, F. Fouqué, F. Zirkel; for geology and palæontology, O. Torell, A. De Lapparent, R. Lepsius; for botany, W. Pfeffer; for zoology and morphology, E. Haeckel, E. van Beneden; for physiology, E. Pflüger, E. Hering.

THE Berlin correspondent of the *Times* reports that the Imperial Government has ordered Prof. Kossel, of the Board of Health, to proceed to Lisbon and Oporto to study the plague and the methods adopted to combat it. Prof. Kossel will be accompanied by Prof. Frosch, of the Berlin Institute, for the Study of Infectious Diseases, who is being despatched on the same mission by the Prussian Government. Drs. Calmette and Salinbeni are already investigating the outbreak, and will report upon it to the Paris Pasteur Institute.

PRINCE KROPOTKIN sends us a note which suggests that the movements of sea-gulls along the British coasts may indicate forthcoming weather changes. On Saturday, August 26, while off Broadstairs, he noticed several flocks of gulls flying along the coast towards Dover. The wind was then blowing from the north-east, as it had been doing throughout August, and there was little indication of a change; but an old fisherman remarked that the gulls which had stayed on the coast at Margate and to the west of it were moving to the south coast to meet a south-west wind, which was sure to come. As is known, the change occurred on the following day, and the wind veered round to the south-west. In connection with this observation, it is worth remark that Mr. Inwards, in his "Weather Lore," says: "The arrival of sea-gulls from the Solway Firth to Holywood, Dumfriesshire, is generally followed by a high wind and heavy rain from the south-west."

THE death is announced of M. Henri Lévêque de Vilmorin, first vice-president of the Paris Société d'Horticulture, and officer of the Legion of Honour.

THE tenth annual general meeting of the Institution of Mining Engineers will be held at Sheffield on September 19-21, under the presidency of Mr. J. A. Longden. Among the subjects of papers to be read or taken as read are:—Instantaneous outbursts of fire-damp and coal at Broad Oak Colliery, by Mr. John Gerrard; Castleton: history, geology, minerals and mining, by Mr. A. H. Stokes; the Peak Cavern, by the Rev. J. M. Mello; the mining districts near Kamloops Lake, British Columbia, by Mr. G. F. Monckton; the Devonian ironores of Asturias, Spain, by Mr. J. A. Jones; alternating currents and their possible applications to mining (Part i.), by Mr. Sydney F. Walker.

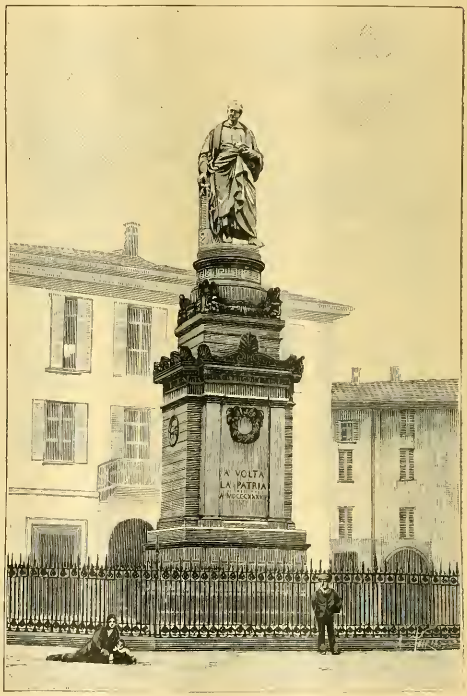
A TEACHER of science with a successful career before him has been lost by the death of Mr. O. G. Jones, who was killed in an accident on the Dent Blanche on August 30. Mr. Jones was appointed to the post of physics master in the City of London School in 1892, when a science side was being organised. He received his training at the Finsbury Technical College and at the Central Technical College, South Kensington, at both of which institutions he held scholarships. He was a B.Sc. of the University of London, where he took first class honours in physics. He possessed high qualities as a teacher, and his sad death will be much regretted.

THE New York *Nation* publishes a few particulars referring to the Danish northern lights expedition which has just left Copenhagen for Iceland. The headquarters will be at Akureyri, a prettily situated little town on Iceland's northern coast. The expedition has been for several months under preparation, and its members have been carefully practised in the use of the instruments, all of the latest construction, which it carries with it. While the headquarters will remain at Akureyri, an auxiliary station will be established on a high hill not far away, and the two stations will be connected both by telephone and by an optical telegraph. The Director of the Danish Meteorological Office, Dr. Adam Paulsen, is at the head of the expedition. He will test his own published theories on the aurora, as well as others advanced by various investigators. Among the instruments to be used are photographic ones, and others of a novel character for the measurement of aerial electricity. Dr. La Cour and Dr. Jantzen are the two chief assistants to Dr. Paulsen, while Count Harold Moltke is attached to the party as its artist. The expedition will return in May 1900.

FROM Schwaz in Tirol to Gloggnitz in Lower Austria the southern boundary of the northern Dolomites and the central zone of the Eastern Alps is marked by a distinct depression, corresponding to a band of palæozoic schists, and evidently produced by denudation. This depression may have been a longitudinal valley, perhaps even in Tertiary times, but it is now drained by five channels which have been eroded across the whole of the northern Dolomites, the valleys of the Inn, the Lake Chiem Ache, the Saalach, the Salzach, and the Enns. In a short but valuable paper, contributed to the current number of the *Mittheilungen* of the Vienna Geographical Society, Prof. C. Diener discusses the relation of each of these valleys to the structure of the rocks through which it has been cut. He finds that in their present form all five are simply results of the erosive action of running water, and their position is practically independent of the complex tectonic structure of the region.

THE scientific aspects of the question of musical pitch were described in last week's NATURE by Mr A. J. Hipkins. A book has now been published containing letters, articles, and comments which have appeared in the press with reference to the proposal to adopt the low pitch throughout the pianoforte trade. The following agreement has been signed by the leaders of the pitch movement in the pianoforte trade:—"The vexed question of a suitable pitch for pianofortes should be settled, and believing that the time has arrived when it can be done effectually, we, the undersigned, after due deliberation, have decided to adopt the Paris diapason normal, but with the allowance for a higher temperature in orchestral performance, accepted since 1896 by the Philharmonic Society—namely, A 439 (C 522) at 68° Fahrenheit. From September 1, 1899, we intend to adopt this pitch as a standard for pianofortes both for retail and wholesale purposes, and will regard the late Philharmonic pitch A 454 (C 540) when required, as an exception, and not, as has been for many years in this country, the rule."

IN commemoration of the centenary of the discovery of the galvanic pile, and in connection with the International Exposition at Como, a statue of Volta has been erected on the Piazza Volta, by public subscription. The accompanying view




of this monument to the pioneer of electrical science is given in *La Nature*. Upon the pedestal of the statue the following words appear:—

OMAGIO
DEI TELEGRAFISTI
D'OGNI NAZIONE
NEL PRIMO CENTENARIO
DELL' INVENZIONE
DELLA PILA
MDCCCXCIX.

As already announced, a National Electrical Congress will be held at Como, in connection with the Volta centenary celebra-

tions, on September 18–23. The congress is being organised by the Associazione Elettrotecnica Italiana and the Società Italiana di Fisica, and the leading foreign scientific authorities have been invited to attend.

THE report of the Director of the Botanical Survey of India, for the year 1898–99, shows that every advantage has been taken of the funds placed at the disposal of the survey for exploration in Burma, Assam and Bengal. A report by Mr. J. F. Duthie, Director of the Botanical Department of Northern India, states that the two parties of plant collectors who left Saharanpur in March 1898 to collect botanical specimens in the forest tracts of the Rohilkhand, Northern Oudh and Gorakhpur districts, collected between them about 1000 species; and also seeds of a large number of trees and shrubs for sowing in the Saharanpur Garden The collections include several very interesting plants, for many of them had not been previously recorded for that part of India, whilst some had not been collected since they were originally discovered by Buchanan-Hamilton and others many years ago.

A BLUE-BOOK just issued, on the number of persons employed, and accidents in mines and quarries in the United Kingdom in 1898 contains several noteworthy points. During the year, 990 separate fatal accidents occurred in and about the mines and quarries, causing the loss of 1075 lives. Compared with the previous year, there was a decrease of twenty-five in the number of fatal accidents and a decrease of twenty-seven in the number of lives lost. When these numbers are considered in relation to the number of persons engaged in the mining industry, it is found that the death-rate in 1898 was the lowest hitherto recorded, viz. 1·28 per thousand as compared with 1·49 for the preceding five years. The improvement commenced in 1895, and has continued steadily down to the present time. It is pointed out that the use of naked lights—always the principal source of danger—is responsible for 147 out of the 163 explosions which occurred, and for sixteen of the twenty-seven deaths. In one of the worst explosions in 1898, it was conclusively proved that the explosion was one of coal-dust alone, and that it was caused by a shot of gunpowder illegally fired in a place which was very hot and dusty. As usual, gunpowder caused far more accidents than any other explosive, and nitroglycerine compounds were responsible for more accidents than nitrate of ammonia compounds.

THE Physical Atlas which has been for about ten years in preparation at the Edinburgh Geographical Institute, under the direction of Mr. J. G. Bartholomew, will be the most comprehensive of its kind ever attempted. A draft prospectus just issued shows that the work will comprise seven volumes and more than two hundred plates. The subjects of these volumes will be geology; orography, hydrography, and oceanography; meteorology; botany; zoology; ethnography and demography; general cosmography and terrestrial magnetism. Berghaus's "Physikalischer Atlas" has been used as the basis of the undertaking; but the present work is much more extensive, and comprises entirely new and original material. Mr. Bartholomew's aim has been to produce a cartographic unification of natural science at the present time, and neither pains nor expense have been spared to make the Atlas a standard one to which men of science may turn with confidence. The meteorology section, with over 400 maps on thirty-four plates, will shortly be published.

AMONG the recent publications of the Deutsche Seewarte we would draw attention to a valuable discussion by Dr. W. Köppen, in vol. xxi. of *Aus dem Archiv*, upon recent determinations of the relation between wind velocity and Beaufort's wind-force scale (0–12). The relatively great expense of anemometers, and the difficulty of obtaining a good exposure for them, are obstacles to their general use, while the employment of the Beaufort scale is necessarily continued at the great majority of observing stations, and at sea. It is therefore important to determine satisfactorily the relation between wind velocity and force. The first serious attempt at this determination was made by Mr. R. H. Scott, in 1875, and the values then obtained still appear in text-books and instructions, although it is now admitted that the instrumental factor 3, which had hitherto been generally used for the conversion of the anemometrical records into miles per hour, is considerably too high. Since that time experiments have been made, notably by Köppen, Sprung, Mohn, Dines, Curtis and others, the general result of which has been to show that the factor in question should be reduced to about 2·2. This result is confirmed by Dr. Köppen's recent investigation, and we understand that, as a result of his inquiries, anemometrical records in all the publications of the Seewarte will in future be reduced to real velocities by this smaller factor. We recommend the careful perusal of Dr. Köppen's paper to all meteorologists.

WE have received from the Secretary to the British Association Committee on Zoological and Botanical Publication a notice to the effect that at the Bristol meeting of the Association the committee was reappointed, with the Rev. T. R. R. Stebbing as chairman, in succession to the late Sir W. H. Flower, and with the addition of Messrs. B. D. Jackson and A. C. Seward as representatives of Botany. It is now proposed to deal with botanical publications; and it is believed that the principles and proposals of the 1897 report will apply with equal force to botanical papers. It is hoped that they may be interpreted in that spirit. It will be well to remind our readers that the recommendations are as follows, viz.:—(1) "That each part of a serial publication should have the date of actual publication, as near as may be, printed on the wrapper, and, when possible, on the last sheet sent to press. (2) That authors' separate copies should be issued with the original pagination and plate-numbers clearly indicated on each page and plate, and with a reference to the original place of publication. (3) That authors' separate copies should not be distributed privately before the paper has been published in the regular manner. (4) That it is desirable to express the subject of one's paper in its title, while keeping the title as concise as possible. (5) That new species should be properly diagnosed, and figured when possible. (6) That new names should not be proposed in irrelevant footnotes or anonymous paragraphs. (7) That references to previous publications should be made fully and correctly if possible, in accordance with one of the recognised sets of rules for quotation, such as that recently adopted by the French Zoological Society."

AN account of the electric welding of tram-rail joints in the city of Buffalo, U.S.A., is given in the *Electrical Review* of August 25. This process of rail welding has been greatly improved, and the results now obtained are seemingly all that can be desired. In Buffalo the bar used for welding is $1 \times 3 \times 8$, and this joining of steel to steel, and the increased carrying capacity owing to the bars at the joints, results in a joint being a place of least resistance. The plant in operation for the purpose of welding consists of five cars. One of these is a sand-blast car which runs in advance of the welding car, and prepares the joint. The other cars are the welding car, the transformer car, the motor and booster car, and a car that follows in the rear to smooth any rough places about the joint. After the welding bars are placed over the joint the jaws of the welder are applied to them, and a pressure of about 1400 lbs. applied by means of a hydraulic jack connected to the upper

end. The current is then turned on, and the metal becomes brighter and brighter until the weld is completed, after which the current is turned off and the pressure increased to about thirty-five tons. While under this pressure the weld is allowed to cool, after which the car is moved back about six inches and the jaws applied to the other end of the bar, where the process is repeated. The other end is treated in the same manner. In other words, the centre weld is made first, and then the end welds. Artificial means of cooling are used, and as the bars cool they exert a powerful influence in bringing the rail ends close, so as to make a tight joint. The current for the operation of the plant is taken from the regular trolley wire service. It would be expected, from considerations of the action of heat upon metals, that rails welded in this way would buckle when they experienced a considerable rise of temperature, or snap when the temperature was very low, but, as a matter of fact, welded rails neither buckle nor break. By applying immense pressure to the material during welding, the length of a continuous rail made by this process is said to have no limit except that of the line itself.

DR. FRANZ BOAS has made a mathematical study (*American Anthropologist*, N.S., i. p. 448) of the biological significance of the cephalic index on the lines suggested by Mr. Francis Galton, and fully developed by Prof. Karl Pearson. His conclusion is that while the cephalic index is a convenient practical expression of the form of the head, it does not express any important anatomical relation. On the other hand, the relation between capacity and head diameters is found to be of fundamental importance, and among these the relation between the transverse diameter and capacity is most significant. Since in measurements on the living we are unable to measure capacity of the head, it is necessary to find a substitute. It would seem that circumferences are the most available means for judging cranial size. Therefore such circumferences should be included in all anthropometrical schedules designed to investigate racial characters.

FROM the Field Columbian Museum we have received Nos. 3 to 6 of the first volume of its "Geological Series" (Chicago, 1899). No. 3 treats of the ores of the South American Republic of Colombia, the specimens being described by Mr. H. W. Nichols, from a collection made by Señor F. Pereira Gamba. The ores were obtained from the mountainous western portion of Colombia, in which the Andes entering from the south divides into three chains known as the eastern, central and western Cordilleras. Gold was first mined by Europeans in Colombia in 1537, and during the sixteenth and seventeenth centuries the country was the great gold producer of the world; now it is said to rank ninth in importance. Iron ore is worked and smelted at Amagá. The authors observe that the gold and silver ores occur either in the acid lavas, which have been erupted at intervals from the close of the Tertiary period to the present time, or in adjacent Archæan schists. In the early days of mining, the superficial weathered rocks, which are the richest, were worked with signal success; the mines are now sunk below this zone. The ores are found in quartz as fissure-veins in the schists, and also as segregations from the surrounding lavas. In the latter case, they appear to have come to the surface in the lavas, from which they have to some extent been leached by hot solfataric waters and by tropical rains.

MESSRS. NEWTON AND CO. inform us that the whole of the lantern exhibitions at the forthcoming meeting of the British Association at Dover are to be carried out by them.

MESSRS. PHILIP HARRIS AND CO., Birmingham, have just published a diary which should be of service to science teachers. The diary covers the year from September 1, 1899, to August 31, 1900; and, in addition to the usual blank pages, contains seventy-six pages of tables and definitions frequently required in physical and chemical laboratories. The book is thus similar to an engineer's pocket-book, and its publication in the form of a diary will make it a constant companion of many science teachers.

MESSRS. R. FRIEDLÄNDER AND SON, Berlin, have issued in a single volume the numbers of *Naturae Novitates* published by them during 1898. It is well known to collectors of scientific books that Messrs. Friedlander's publication contains a useful classified list of current literature on all branches of science, compiled from catalogues in many languages. It is convenient to have these bibliographical lists in volume form, and a full index at the end increases their value.

THE additions to the Zoological Society's Gardens during the past week include a Sykes's Monkey (*Cercopithecus albigularis*, ♂) from South Africa, presented by Mr. W. P. Peyton; a Common Camel (*Camelus dromedarius*, ♂) from Mogador, presented by Mr. F. G. Aflalo; a Stone Curlew (*Oedicnemus scolopax*), European, presented by Mr. S. M. Sargant; a Common Raccoon (*Procyon lotor*) from Barbados, deposited.

ERRATA.—Lord Kelvin asks us to notify the following errata in the MS. of his letter on the "Blue Ray of Sunrise over Mont Blanc," published last week (p. 411):—Line 1, for 5 o'clock read 4 o'clock; line 7, after "light" insert "of sunrise."

## *OUR ASTRONOMICAL COLUMN.*

HOLMES' COMET 1899 *d* (1892 III.).—

*Ephemeris for 12h. Greenwich Mean Time.*

| 1899. | | R.A. | | | Decl. | | | Br | |
|---|---|---|---|---|---|---|---|---|---|
| | | h. | m. | s. | ° | ′ | ″ | | |
| Sept. | 7 | 2 | 6 | 50 14 | +41 | 41 | 40·0 | | |
| | 8 | | 7 | 15·57 | 41 | 55 | 35·8 | | |
| | 9 | | 7 | 39·02 | 42 | 9 | 25·3 | 0·1814 | 0·05435 |
| | 10 | | 8 | 0·45 | 42 | 23 | 8·0 | | |
| | 11 | | 8 | 19·84 | 42 | 36 | 43·8 | | |
| | 12 | | 8 | 37·16 | 42 | 50 | 12·4 | | |
| | 13 | | 8 | 52·40 | 43 | 3 | 33·5 | 0·1795 | 0·05538 |
| | 14 | 2 | 9 | 5·51 | +43 | 16 | 46·9 | | |

During the week the comet passes through the north-west of Andromeda, being a few degrees west of γ Andromedæ on the 11th. It is in a good position for observation, but is reported as extremely faint.

In *Popular Astronomy* (vol. vii. pp. 340–342) Prof. C. D. Perrine describes the circumstances of his rediscovery of this comet on June 11 of the present year. The observation was made in the early morning with the 36-inch Lick refractor, the atmospheric conditions being very good. The comet appeared as a round nebulous mass about 30″ in diameter, very faint and with but little central condensation. The orbit is more nearly circular than that of any other known comet, lying wholly between the orbits of Mars and Jupiter, thus suggesting a possible, but as yet unproved, connection with the asteroids also occupying that position.

THE NEW ALGOL VARIABLE IN CYGNUS.—The following are the predicted minima of this newly-discovered variable, which will admit of observation during September:—

| | | d. h. m. |
|---|---|---|
| 1899, September | ... | 12 11 58 G.M.T. |
| | | 21 15 27 |

Mr. J. A. Parkhurst gives (*Popular Astronomy*, August 1899, vol. vii. p. 380) two charts of the stars in the neighbourhood, which will greatly facilitate the detection of the variable. Observations may be satisfactorily made with telescopes of 3 inches aperture. The position is about 1° south preceding the 5th mag. star $o^1$ Cygni.

HARVARD COLLEGE OBSERVATORY.—Prof. Pickering has recently issued the second part of vol. xxiv. of *Annals of Harvard College Observatory*, containing an exhaustive discus-

sion of the observations made with the meridian photometer during the period 1882–88. The magnitudes, as given in the "Harvard Photometry," are compared with both the "Uranometria Argentina" and the *Bonn Durchmusterung*.

For the greater part there is close agreement, but the magnitudes in the *Bonn Durchmusterung* are found to have a systematic variation according to the right ascension, the stars grouped at about R.A. 7h., in the Milky Way near Monoceros, being more affected than others also in the Milky Way, but at R.A. 18–19h., in Aquila.

Part of the differences between the "Harvard Photometry" values and those of the "Uranometria Argentina" are ascribed to the difference in position of the two stations, as the zenith distances of the stars would be different, and therefore, presumably, the atmospheric absorption; no correction being applied for this, the southern stars at Cordoba would be estimated too bright.

An attempt to revise the scale of the *Durchmusterung* decided that it was practically impossible to reduce it to the photometric scale by any simple rule, and for purposes of comparison the necessary corrections are given to convert one scale into the other from magnitudes 1·0 to 9·2.

Pages 185–233 are devoted to a discussion of the relation between the magnitudes in the *Harvard Photometry* and those determined by Sir William Herschel. Of the six catalogues of Herschel's observations, the third is considered more accurate, and the fifth less so, than the others. In all he published observations of 3000 stars, and the *average* difference from the photometric catalogues of the present day is only $\pm 0{\cdot}16$ magnitude, this including both the possible change during the century which has elapsed and the errors of both determinations. Prof. Pickering is surprised that these observations should not have been repeated at intervals of ten or twenty years, so that deviations of individual stars might be detected. With this idea he gives a special table including all stars in which the difference between Herschel's magnitudes and the photometric ones equals or exceeds half a magnitude.

The remainder of the volume, pp. 234–245, deals with investigations in regard to the relative performance of the large and small meridian photometers which have been employed in the production of the *Harvard Photometry* itself. No difference exceeding the hundredth of a magnitude was detected. Tables are given showing that the values of the *Harvard Photometry* are not sensibly affected by variations of magnitude, right ascension, declination, or proximity to the Milky Way.

## TORSION-STRUCTURE IN THE ALPS.[1]

ONE of the most brilliant and suggestive chapters in Suess' monumental work "Das Antlitz der Erde" is that in which he deals with the remarkable whirl shaped arrangement of the leading lines of the Alpine system (vol. i. chap. 2).

Prof. Suess describes how the "leading line" sweeps round the north in one great curve convex to the north, the Apennines describe a curve convex towards the east, whereas the Dalmatian mountains form opposite it a curve convex to the west; and the curve of the Apennines is continued westward along the Algerian ranges of North Africa, whereas the Dalmatian curve is continued eastward towards Asia Minor. Prof. Suess points out that movements of crust-folding have always taken place towards the convex or outer side of these curves, and have in most cases caused an actual transgression of the curves above the regions in front of them. He further states that it is not fully understood why the mountain-systems should follow curved lines, or why the curves of the Alpine upheaval should in many areas repeat those of former mountain-systems.

Let me, before going further, remind the reader of a lecture given by one of the greatest of stratigraphers, Prof. Lapworth, at a meeting of the Royal Geographical Society five years ago, and reported in these pages ("The Face of the Earth," NATURE, April 26, 1894). This lecture set forth the conception of crust-torsion, demonstrating that "like the present surface of a typical geological formation . . . the surface of the earth-crust at the present day is most simply regarded as the surface of a continuous sheet which has been warped up by the two sets of undulations crossing each other at right angles. But in the case of the earth-surface, the one set of undulations ranges parallel with the equator, and the other ranges from pole to pole."

Prof. Lössen's explanation of the involved stratigraphy of the Harz mountains lays the foundation of our knowledge of torsion phenomena in the field, and, although other explanations have been given of the special difficulties in the Harz mountains, Prof. Lössen's is now generally accepted.

When working out the detailed stratigraphy of a part of the Dolomites, I experienced the same difficulties which Prof. Suess had indicated in connection with the "whirled lines" of the Alpine system generally. My results were laid before the Geological Society in December 1898, and are now published in the August issue of the *Quart. Journ. Geol. Soc.*, along with a stratigraphical map of the district examined. In that paper I have tried to show that the possible solution of some of the difficulties lies in the association of torsional movements in conflicting directions through the crust, with movements of crust-folding taking place across a pre-existing set of crust-folds. The *change in the direction of the resultant earth-thrust* is the cause to which I have ascribed the torsional phenomena observed in the crust-folds.

The following notes will indicate as briefly as possible wherein the characteristic features of Sella and Enneberg in the Dolomites are analogous with characteristic features of the Alpine system, and how far the elucidation I have offered for that area on the lines of torsion may be capable of a wider application.

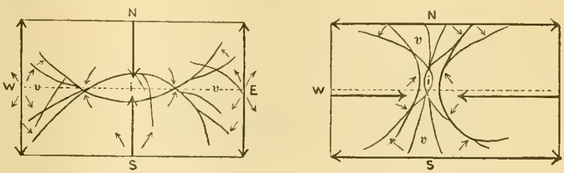



FIG. 1.—Formation of fold-arcs under the influence of torsion-forces. *i*, areas of interference; *v*, areas of virgation.

The stratigraphy of Sella and Enneberg is characterised by twisted strikes, twisted cleavages, twisted arches, twisted troughs, twisted faults, twisted dykes and sills—in fact, the rocks have been twisted and sheared to such a degree that thick deposits have been twined into the form of rock-whorls and large masses of limestone for the greater part changed to dolomite. The various combinations of twisted strikes produce the effect of "whirled" stratigraphical lines round individual centres of the region examined. Sigmoid curves in one direction are correlated with sigmoid curves in another, and arcs which are convex towards north and south are connected by virgating lines with arcs which are convex towards east and west.

Thus we may say that the curves round the north, east, and south of the Sella mountain resemble the "whirl-shaped leading lines" of the Riviera Alps, Apennines and Algerian mountains round the western basin of the Mediterranean Sea; while the curves round the north, west, and south of the Prälongia and Sett Sass area resemble the whirl-shaped lines of the Dalmatian and Pindus mountains and the curvature through the eastern basin of the Mediterranean Sea. The latter curvature resembles that of the mountains around the Roumanian plain, or of the Alps round the plain of Piedmont.

Examples might be multiplied interminably, and on great and small scale, *the reason being that the essential structure of the Alpine system is based upon spirally twisted folds, and not upon linear anticlines and synclines.*

The formation of fold-arcs is illustrated in the accompanying diagrams (Fig. 1), which show that the action of one torsion-couple must be compensated by the reverse action of a correlated torsion-couple, and a fold-arc convex towards one compass direction must be coordinated with a fold-arc convex towards the opposite compass direction. When the convexities approach one another during torsional movements the result is that oppositely-curved fold-arcs intertwine in an area which may be

[1] Condensed from the concluding chapter, "Application to the Alps," in a paper presented at the Roy. Geol. Soc., December 1898.

termed an area of "interference," to distinguish it from the areas of "virgation" where fold-arcs curve away from one another.

A fold-arc is not a homogeneous fold, but is made up of a series of unit-folds, each of which is the segmental portion of a curve. Any one fold, as it were, dies out in its particular direction and horizon, but is replaced by a fold in the next part of the curve passing through slightly different horizons of the crust. Thus the arc round which a series of unit-folds is arranged comes under the category of curves that change their plane.

In Enneberg, series of fold-arcs with their convexities towards different compass directions have been overcast, and the overcast folds have been penetrated by reverse and normal fault-planes, reverse movement having taken place in the subjacent slices of the overcast folds. But, combined with reverse movements in virtue of vertical components, there have been converse movements in virtue of torsional components, so that the actual resultant movement has been spiral—*e.g.* while the middle or "arch" slice of an overcast fold moved in clockwise direction and outward, the upper and under slices of the same fold moved in counter-clockwise direction and inward.

The problem resolves itself into involute and evolute movements of crust-slices with reference to central areas, the evolute slices tending ever to spread, the involute slices ever to narrow.

Shear-breccias and fragmentary portions of folds fill up the inwardly-tilted troughs. The fault-rocks in certain of the sheared and twisted troughs of Enneberg had been formerly treated as independent zones of rock, and termed "Buchenstein Agglomerate"; but in my paper they are shown to be practically a "Flysch conglomerate," formed during the Tertiary epoch of Alpine upheaval.

The "Flysch" troughs which appear round the Alpine curves may possibly be explained as the result of similar processes of involute and evolute movements going on in slices of closely-piled overcast folds. Thus we might have troughs being twisted inwards and gathering "Flysch" in variable fragments, while evolute slices of the reciprocal arches were being twisted outwards. The "Klippen," and even the "Klippen" ranges, may represent such "arch" wedges of fold-arcs originally closely piled and jammed as the fold-arcs are round the dolomite massives.

There is abundant evidence in Enneberg that the molten layers immediately below the crust have shared in the movements of torsional-folding. They have filled the body of the virgating fold-arcs produced by these movements, and have there been incorporated in the local crust-whirl of torsion-movements, finding inlet into the planes of fold-shearing, and being dragged and twisted along with adjacent fault-blocks. An inrush during earlier phases of torsion has been in its turn invaded by the next inrush, and so on, in accordance with the gradual progress of torsion; the latest invasions occur along transverse and oblique faults, belonging to a system of faults which has affected Oligocene strata in the Judicarian area; hence such injected rock is not older than Middle Tertiary.

The fundamental feature of torsional folding may be said to be centralisation; whether it be involution of certain horizons in covered troughs, or evolution of other horizons in overcast arches, the movements have reference to the centres of torsion-basins and torsion-buckles.

The principles thus demonstrated in Enneberg will be seen to involve the "fan-shaped structure" of central massives. They could not fail to do so, since they have been deduced from the stratigraphy of Sella massive in Enneberg, which presents a wonderfully symmetrical, although obliquely elongated example of "fan-structure."

I have shown in my paper on Enneberg that the transverse faults define a later or Tertiary series of arches and troughs, through whose septal portions they chiefly pass. The faults are shearing-planes, and are the result of oppositely-directed movements of twisting and thrusting which have taken place from opposite arches upon common reciprocals, the intermediate troughs. These movements have produced the virgating groups of north and south fold-arcs which meet the east and west fold-arcs, and the sigmoidal combinations of torsional fold-arcs and fault-curves represented in Fig. 2.

The continuance of the faulting during a protracted period of crust-adjustment has caused displacement of the arcs on the opposite sides.

There are several well-known lines of tranverse and oblique shearing through the Alps which repeat these phenomena on a larger scale, and at the same time no detail is wanting in the comparison. Some of these may be indicated: (1) The Judicarian-fault; (2) Iseo-Ortler; (3) Como-Sonthofen; (4) Maggiore-Sargans; (5) Tarentaise-Thun; (6) Savoy-Freyburg—all these represent directions of inthrow and faulting along the "septum" or "middle limb" between great transverse arches and troughs which form part of major Alpine torsion-curves.

With regard to the eastern Alps, there are also well-marked N.N.E.-S.S.W. directions of faulting and displacement. The pre-eminent example is the remarkable series of down-throws at the eastern limit of the Alps, with which is associated the displacement of the northern curve of the Alps towards the Carpathian curve. At the same time, the influence of the co-ordinated torsional movements round the Hungarian basin is evidenced in the eastern Alps by N.N.W.-S.S.E. directions of transverse-shearing.

All the transverse directions of tectonic disturbance in the Alps have in common with the parallel Enneberg lines (*a*) the

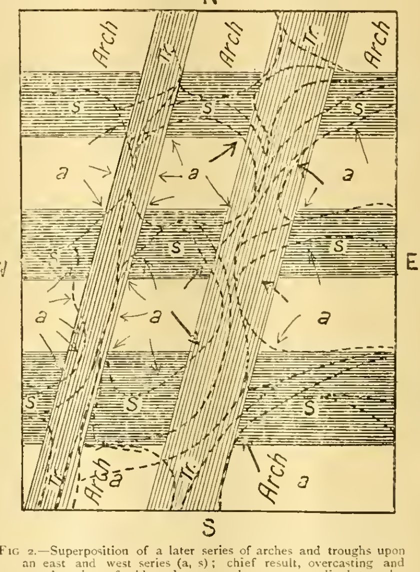



FIG. 2.—Superposition of a later series of arches and troughs upon an east and west series (a, s); chief result, overcasting and overthrusting of old and new arches over synclinal troughs. - - - - fold-curves and faults formed by the twisted shearing.

virgation from them of an eastern and western series of torsion-curves, representing fold-arcs; (*b*) the injection of igneous rock along the main direction of "septal" shearing, associated with the presence of larger masses in the areas of fold-expansion; (*c*) the fact that they have continued to act as lines of crust-adjustment subsequently to the period of acute torsional upheaval. In the Alps the repeated displacement of the main chain to the north would simply indicate that the arch on the east of any transverse depression had been originally less elevated than the arch on the west of the same depression. The extent to which eastern curves have been twisted away from western curves originally belonging to the same "bundle" of virgating folds, may give us some idea of the tremendous shearing that has taken place, and the great compression that the Alpine regions have sustained from east and west in virtue of this oblique, sigmoidal movement of opposite arches over intervening synclines (Fig. 3).

The law which I deduced from my observations at Sella was that the southwardly-convex torsion curves are marked by over-

thrust of the folds towards the south, the northwardly-convex curves by overthrust of the folds towards the north. This law agrees with the movements which Prof. Suess has described along the curved lines of Alpine upheaval, and finds further confirmation in the curious effects of reversal of thrust-movements which are so highly characteristic of all the great transverse Alpine arches. To cite one example, compare the great overthrusts round the south curves of the western Alps with the northwardly-directed overthrusts in the Bernese Oberland.

The drawing (Fig. 3) shows that the eastern and western fold-arcs associated with any transverse direction of faulting provide the same fundamental conditions of peripheral overthrusts with reference to definite centres which I demonstrated in Enneberg. And as the centres are comprised in the very highest transverse Alpine arches which were determined during the later epoch of Alpine upheaval, it is here that, according to torsional laws, the highest individual massives should be present.

The essential structure is the same, whether it be exemplified in the variously-shaped dolomite massives or in the variously-shaped central massives—elliptical, lenticular, or elongated, clearly or less clearly defined from one another—all may be regarded as an inevitable result of crust-torsion.

Even when considerable subsequent faulting and lateral displacement might seem to have obliterated the original relationship of opposite torsion-curves, there are long streaks or interrupted appearances of igneous injections along the main fault-line, which afford evidence of a probable original connection between eastern and western fold-arcs now fairly remote from one another.

The more or less sickle-shaped form of some Alpine curves represents a north and south fold-arc on the same side of a transverse direction of shearing. The Enneberg curve (Langs-da-Für, Campolungo, Cherz Hill) is an example on a small scale, the Banat curve round the Roumanian Plain is an example on a grand scale.

The chief line of fault there is the "Banat" line, which in its tectonic relations bears a strong resemblance to the Judicarian line. It runs north and south and separates a western area of mica schists from an eastern depressed area of Jurassic and Cretaceous strata, eruptive rocks occurring at intervals along the fault. In describing the Banat fault, Prof. Suess never doubts the Tertiary age of the folds and of the eruptive rocks associated both with the folds and with the fault. He notes the twisting character of the strike, and expressly states that the eruptive rocks "*must have been Tertiary notwithstanding the resemblance almost amounting to identity which they present with those of the Judicarian and Predazzo areas*" ("Antlitz," i. p. 623 and pp. 210-213; the italics are mine). Further, he quotes Dr. Posepny's opinion "that these eruptive masses are not masses exerting pressure, but themselves pressed. The subsidence of a neighbouring district induces such eruptions, but the eruptive masses themselves are pressed into the dykes by the pressure of the sinking masses" (*l. c.* p. 210). Similar reasoning was followed by Dr. Salomon in his paper on the Peri-Adriatic eruptive masses, wherein he advocated the theory that the Peri-Adriatic masses originated in consequence of the Peri-Adriatic subsidence, and were of the age of the subsidence.

I would be inclined to class both the Judicarian and Banat faults as phenomena of torsional eruptivity which may, upon the evidence of the sedimentary strata involved in the folds, be referred to the Mid-Tertiary epoch of Alpine upheaval.

Two great internal torsion-basins within the Alpine systems of southern Europe are the Hungarian and the west Mediterranean. The arrangement of the Carpathian mountains round the Hungarian basin presents all the characteristic features of torsion. Mountain fold-arcs have formed peripherally, and broken arches have been thrust outwards and upwards from the basin, while fold-slices produced by normal faulting have had an involute movement inward and downward. Eruptivity has been particularly active in the main septal zone between the oppositely moving portions of the fold-arcs. The Dalmatian mountains represent a series of peripheral folds whose arches have moved towards the south-west, while the eastern Alps betray the influence of this movement of folding, and also a co-ordinated movement to north-west.

The centrifugal movements round the periphery of the western part of the Mediterranean basin have caused the upfolding of the Apennines towards the north-east, and again an igneous zone runs irregularly between the area of peripheral out-thrust and inward down-throw. It is still further within the igneous zone that we must look for the buckling-up of new rock-folds, but the new folds can never be absolutely parallel with the predecessors, *since crust-torsion is going on all the time.* Hence the virgation of successively formed ranges in great mountain systems would appear to rest upon much the same principle as the virgation of fold-arcs illustrated at Gröden Pass in Enneberg (*Q.J.G.S.*, August 1899, *l.c.*, Plate I.).

While torsion-basins tend by reason of repeated buckling to narrow within themselves, the tendency of the regions outside the outermost peripheral fold-arcs is to subside towards the torsional sag. To such return involute movements we may probably attribute the present subsidence going on in the Adriatic areas, as also the tendency for lakes and plains to form on the outer skirts of torsional mountain-systems.

The Caucasus mountains afford an example of the occurrence of an internal area of down-throw in various parts of which

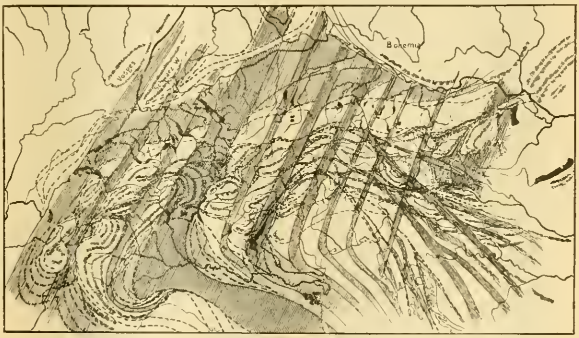


FIG. 3.—The leading oblique arches and troughs of the Tertiary upheaval of the Alps. (The troughs are shaded, the arches are between the troughs, and the chief fold-arcs of the mountain masses are indicated within the arches by shading and broken lines.)

vulcanicity has been active, and of outer areas along which overcast folds of immense size have been gradually involuted. The Alps show at the present day an advanced phase in their torsional history. Earlier outer folds have been broken down owing to dynamic as well as aërial causes of denudation, and have disappeared along interrupted outer shear-zones which I would identify as those occupied by "Flysch" rocks of whatever age. These rocks represent the necessary deformation of older and less twisted folds by the process of involution during the gradual evolution of later and more twisted folds.

Such an explanation of the relation of the Flysch to the present Alps would agree with the observed fact that fragments of granitoid and metamorphic rocks contained in the Flysch show less metamorphic change than those in the central massives of the Alps, since it would relate the Flysch to lost earlier folds which had undergone a smaller degree of torsion than the succeeding folds.

The widely-extended subsidence during Jurassic and the greater part of Cretaceous time in Europe seems to have been the turning-point in the history of Alpine upheaval, since previously, in Alpine regions, the resultant forces had acted more strongly from north and south than from east and west, and afterwards the movements came almost transversely. Hence the long continuation of the great Mesozoic epoch of deposition and subsidence, in inducing the strong action of east and west crust-strains over a region where previously the action of north and south crust-

strains had been pre-eminent, has probably been the initiative cause of an acute epoch of crust torsion and folding along oblique and transverse lines.

The new movements affected all European areas, dovetailing new folds into the midst of, and across, old folds, and determining new centres of virgation. In the Alps new arches and troughs were formed obliquely and transversely across the older series; the first-formed basins in the new movement were themselves over-arched or blocked up as the fan-shaped mountain-massives gradually became more and more compactly pressed together, and the great torsion-basins of southern Europe became confirmed in their new shape and position acquired in accordance with the altered conditions of crust equilibrium.

As might be expected, there is frequent indication that eruptive activity in Tertiary time broke out afresh in the same areas where eruptive activity had marked the Upper Carboniferous and Permo-Triassic period of movements. But the chief groups of eruptive rock round the inner *curves* of the Alps, Apennines and Carpathians, as well as the injections along oblique directions of shearing, may be clearly identified with the Tertiary torsion movements, for the most part, with the acute Mid-Tertiary epoch of torsion. The larger masses of igneous rocks in the central massives may belong in part to the ancient Palæozoic or Permo-Carboniferous epochs of upheaval, in part to the late-Mesozoic and Tertiary epochs.

A general conclusion may be made from the above that there are serpentines, diorites, granites, felsites, basalts in Alpine folds and faults which can be identified more especially with the "evolute" phenomena of Tertiary torsional movements. And these intrusions, injections, and eruptions involved in the last acute epoch of upheaval in Southern Europe are clearly correlated with similar eruptive phenomena throughout the same period in other parts of Europe, *e.g.* Auvergne, Scotland, Iceland.

MARIA M. OGILVIE.

## THE MOTION OF A PERFECT LIQUID.[1]

IF we look across the surface of a river, we cannot fail to observe the difference of the movement at various points. Near one bank the velocity may be much less than near the other, and generally, though not always, it is greater in the middle than near either bank. If we could look beneath the surface and see what was going on there, we should find that the velocity was not so great near the bottom as at the top, and was scarcely the same at any two points of the depth. The more we study the matter, the more complex the motion appears to be; small floating bodies are not only carried down at different speeds and across each other's paths, but are whirled round and round in small whirlpools, sometimes even disappearing for a time beneath the surface. By watching floating bodies we can sometimes realise these complex movements, but they may take place without giving the slightest evidence of their existence.

You are now looking at water flowing through a channel of varying cross section, but there is very little evidence of any disturbance taking place. By admitting colour, although its effect is at once visible on the water, it does not help us much to understand the character of the flow. If, however, fine bubbles of air are admitted, we at once perceive (Fig. 1) the tumultuous conditions under which the water is moving and that there is a strong whirlpool action. This may be intensified by closing in two sides (Fig. 2), so as to imitate the action of a sluice gate, through the narrow opening of which the water has all to pass, the presence of air making the disturbed behaviour of the water very evident.

FIG. 1

FIG. 2.

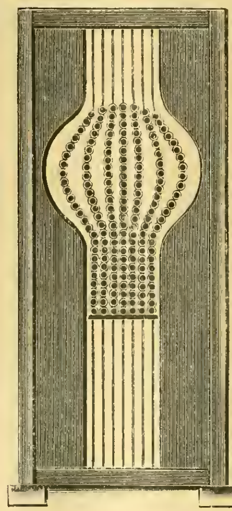


FIG. 3.

Now you will readily admit that it is hopeless to begin to study the flow of the water under such conditions, and we naturally ask, are there not cases in which the action is more simple? Such would be the case if the water flowed very slowly in a perfectly smooth and parallel river bed, when the particles would follow one another in lines called "stream-lines," and the flow would be like the march of a disciplined army, instead of like the movement of a disorderly crowd, in which free fights taking place at various points may be supposed to resemble the local disturbances of whirlpools or vortices.

The model (Fig. 3) represents on a large scale a section of the channel already shown, in which groups of particles of the water are indicated by round balls, lines in the direction of flow of these groups (which for convenience we may call particles) being coloured alternately. When I move these so that the lines are maintained, we imitate "stream-line" motion, and when, at any given point of the pipe, the succeeding particles always move at exactly the same velocity, we have what is understood as "steady motion."

[1] A discourse delivered at the Royal Institution on Friday, February 10, by Prof. H. S. Hele-Shaw.

As long as all the particles move in the straight portion of the channel, their behaviour is easy enough to understand. But as the channel widens out, it is clear that this model does not give us the proper distribution. In the model the wider portions are not filled up, as they would be with the natural fluid; for it must be clearly understood that the stream-lines do not flow on as the balls along these wires, passing through a mass of dead water, but redistribute themselves so that every particle of water takes part in the flow. Perhaps you may think that if these wires were removed, and the wooden balls allowed to find their own positions, they would group themselves as with an actual liquid. This is not the case; and, for reasons that you will see presently, no model of this kind would give us the real conditions of actual flow. By means of a model, however, we may be able to understand why it is so absolutely essential we should realise the correct nature of the grouping which occurs.

First look at the two diagrams (Figs. 4 and 5), which you will see represent channels of similar form to the experimental one. The same number of particles enter and leave in each under apparently the same conditions, so that the idea may naturally arise in your minds, that if the particles ultimately flow with the same speed whatever their grouping in the larger portion of the channel, it cannot much matter in what particular kind of formation they actually pass through that wider portion. To understand that is really very important. Let us consider a

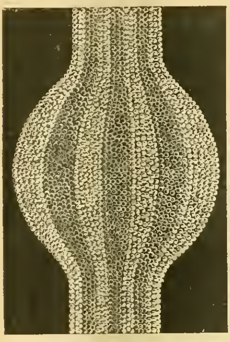


FIG. 4.

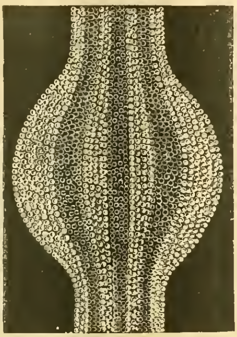


FIG. 5.

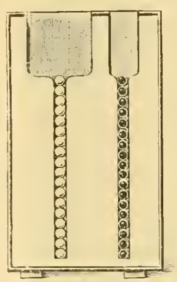


FIG. 6.

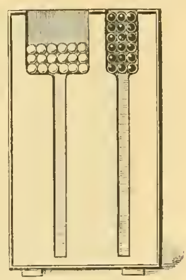


FIG. 7.

model (Fig. 6) specially made for the purpose. You will see that we have two lines of particles which we may consider stream-lines, those on the left coloured white, and those on the right coloured red. The first and last are now exactly 18 inches apart, there being eighteen balls of 1 inch diameter in the row. If I move the red ones upward, I cause them to enter a wider portion of the channel, where they will have to arrange themselves so as to be three abreast (Fig. 7). It is quite clear to you, that as I do this their speed in the wider portion of the channel is only one-third of that in the narrow portion, as you will see from the relative positions of the marked particles. Now, directly the first particle entered the wider channel, it commenced to move at a reduced speed, with the result that the particles immediately behind it must have run up against it, exactly in the same way that you have often heard the trucks in a goods train run in succession upon the ones in front, when the speed of the engine is reduced; and you will doubtless have noticed that it was not necessary for the engine actually to stop in order that this might take place. Moreover, the force of the impact depended largely upon the suddenness with which the speed of those in front was reduced. Applying this illustration to the model, you will see that the impact of these particles in the wider portion would necessarily involve a greater pressure in that part. Turning next to the white balls, I imitate, by means of the left-hand portion, the flow which will occur in a channel six times as large as the original one, and you now see (Fig. 7) that as the particles have placed themselves six abreast, and the first and last row are 3 inches apart instead of 18 inches, the speed in the wider portion of the channel must have been one-sixth of that in the narrow portion. Evidently, therefore, the velocity of the particles has been reduced more rapidly than in the previous case, and the pressure must consequently be correspondingly greater.

We may now take it as perfectly clear and evident, that the pressure is greater in the wider portion and less in the narrower portion of the channel. Turning now to the two diagrams, we see that the pressure is in each case greater in every row of particles as in the wider portions of the channel, but that instead of being suddenly increased, as in the model, it is gradually increased. The width of the coloured bands, that is, rows of particles, or width apart of stream-lines, is a measure of the increased pressure. Thus you will now regard the width of the bands, or what is the same thing, the distance apart of the stream-lines, as a direct indication of pressure, and the narrowness or closeness of the stream-lines as a direct indication of velocity.

Next notice the great difference between the two diagrams. In one diagram (Fig. 4) the change of width is uniform across the entire section. In diagram (Fig. 5), however, this is not the case. In the narrowest portion of the channel in each diagram there are seven colour bands of little balls each containing three abreast, but we find that in one diagram (Fig. 4) they are equally spaced in the wider part six abreast throughout. In the other diagram (Fig. 5) the outer row is spaced eight abreast, the second row rather more than six, and the inner rows rather more than four abreast, and the middle row less than four abreast, making in all forty-two in a row, as in the previous case. One diagram (Fig. 5) therefore will represent an entirely different condition to the state represented by the other diagram (Fig. 4), the pressure in the wide part of the latter varying from a maximum at the outside to a minimum in the middle, while the corresponding velocity is greatest in the middle and least at the outside or borders.

Now, when we know the pressure at every point of a liquid, and also the direction in which the particles are moving, together with their velocity at every point, we really know all about its motion, and you will see how important the question of grouping is, and that, in fact, it really constitutes the whole point of my lecture to-night. How then shall we ascertain which of the two groupings (Fig. 4 or 5) is correct, or whether possibly some grouping totally different from either does not represent the real conditions of flow?

Now, the model does not help us very far, because there seems to be no means of making the grouping follow any regular law which might agree with fluid motion. In whatever way we improve such a model, we can scarcely hope to imitate by merely mechanical means the motion of an actual liquid, for reasons which I will now try to explain.

In the first place, apart from the particles having no distinguishing characteristics, either when the liquid is opaque or transparent, they are so small and their number is so great as to be almost beyond our powers of comprehension. Let me try, by means of a simple illustration, to give some idea of their number, as arrived at by perfectly well recognised methods of physical computation. Lord Kelvin has used the illustration that, supposing a drop of water were magnified to the size of the

earth, the ultimate particles would appear to us between the size of cricket-balls and foot-balls. I venture to put the same fact in another way, that may perhaps strike you more forcibly. This tumbler contains half a pint of water. I now close the top. Suppose that, by means of a fine hole, I allow one and a half billion particles to flow out per second—that is to say, an exodus equal to about one thousand times the population of the world in each second,—the time required to empty the glass would be *between* (for of course we can only give certain limits) seven million and forty-seven million years.

In the next place, we have the particles interfering with each other's movements by what we call "viscosity."

Of course, the general idea of what is meant by a "viscous" fluid is familiar to everybody, as that quality which treacle and tar possess in a marked degree, glycerine to a less extent, water to a less extent than glycerine, and alcohol and spirits least of all. In liquids, the property of viscosity resembles a certain positive "stickiness" of the particles to themselves and to other bodies; and would be well represented in our model by coating over the various balls with some viscous material, or by the clinging together, which might take place by the individuals of a crowd, as contrasted with the absence of this in the case of no viscosity as represented by the evolutions of a body of soldiers. It may be accounted for, to a certain extent, by supposing the particles to possess an irregular shape, or to constantly move across each other's paths, causing groups of particles to be whirled round together.

Whatever the real nature of viscosity is, it results in producing in water the eddying motion which would be perfectly impossible if viscosity were absent, and which makes the problem of the motion of an imperfect liquid so difficult and perplexing.

Now, all scientific advance in discovering the laws of nature has been made by first simplifying the problem and reducing it to certain ideal conditions, and this is what mathematicians have done in studying the motion of a liquid.

We have already seen what almost countless millions of particles must exist in a very small space, and it does require a much greater stretch of the imagination to consider their number altogether without limit. If we then assume that a liquid has no viscosity, and that it is incompressible, and that the number of particles is infinite, we arrive at a state of things which would be represented in the case of the model or the diagram on the wall, when the little globes were perfectly smooth, perfectly round and perfectly hard, all of them in contact with each other, and with an unlimited number occupying the smallest part of one of the coloured or clear bands. This agrees with the mathematical conception of a perfect liquid, although the mathematician has in his mind the idea of something of the nature of a jelly consisting of such small particles, rather than of the separate particles themselves. The solution of the problem of the grouping of the little particles, upon which so much depends, and which may have at first seemed so simple a matter, really represents, though as yet applied to only a few simple cases, one of the most remarkable instances of the power of higher mathematics, and one of the greatest achievements of mathematical genius.

You will be as glad as I am that it is not my business to-night to explain the mathematical processes by which the behaviour of a perfect liquid has been to a certain extent investigated. You will also understand why such models as we could actually make, or any analogy with the things with which we are familiar, would not help us very much in obtaining a mental picture of the behaviour of a perfect liquid. If, for instance, we try to make use of the idea of drilled soldiers, and move the lines with that object in view, we see that instead of the ordinary methods of drill, the middle rank soon gains on the others, and enters again the parallel portion of the channel in a very different relative position to the opposite lines, although the stream-lines would all have the same actual velocity when once again in the parallel portion. Since, then, we cannot use models or any simple analogy with familiar things, or follow—at any rate this evening—the mathematical methods of dealing with the problem, what way of understanding the subject is left to us?

If we take two sheets of glass, and bring them nearly close together, leaving only a space the thickness of a thin card or piece of paper, and then by suitable means cause liquid to flow under pressure between them, the very property of viscosity, which, as before noted, is the cause of the eddying motion in large bodies of water, in the present case greatly limits the freedom of motion of the fluid between the two sheets of glass, and thus prevents, not only eddying or whirling motion, but also counteracts the effect of inertia. Every particle is then compelled by the pressure behind and around it to move onwards without whirling motion, following the path which corresponds exactly with the stream-lines in a perfect liquid.

If we now, by a suitable means, allow distinguishing bands of coloured liquid to take part in the general flow, we are able to imitate exactly the conditions we are seeking to understand.

[Prof. Hele-Shaw here gave demonstrations of the stream-lines in liquids flowing under the conditions of a gradually enlarging and contracting channel. He proved that the condition of flow corresponded closely with that shown in Fig. 5 and *not* with that given in Fig. 4. The method of the experiments has already been described in NATURE (vol. lviii. p. 34), though by using glycerine instead of water much more perfect results were obtained than in those then described.]

But at this stage you may reasonably inquire how it is that we are able to state, with so much certainty, that the artificial conditions of flow with a viscous liquid are really giving us the stream-line motion of a perfect one; and this brings me to the results which mathematicians have obtained.

The view now shown represents a body of circular cross-section, past which a fluid of infinite extent is moving, and the lines are plotted from mathematical investigation and represents the flow of particles. This particular case gives us the means

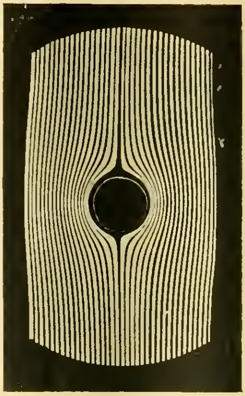


FIG. 8.

of most elaborate comparison; although we cannot employ a fluid of infinite extent, we can prepare the border of the channel to correspond with any one of the particular stream-lines, and measure the exact positions of the lines inside.

By means of a second lantern, the real flow of a viscous liquid for this case is shown upon the second screen, and you will see that it agrees with the calculated flow round a similar obstacle of a perfect liquid. The diagram shown on the wall is the actual figure employed for comparison, and upon which the experimental case was projected. By this means, it was proved that the two were in absolute agreement. If we start the impulses, as before, in a row, we at once see how the middle particles lag behind the outer ones, as indicated by the width of the bands, showing that it is not necessarily the side stream-lines that move more slowly. It may be more interesting to you to see, in addition to the foregoing case in which for convenience, and as quite sufficient for measurement only, a semi-cylinder was employed—the case of a complete cylinder (Fig. 8). In this case two different colours are used in alternate bands, and these bands are sent in, not steadily, but impulsively, in order to illustrate what I have just pointed out. You will see how the greater width of the colour bands before and behind the cylinder indicates an increase of pressure in those regions. This in a ship-shape form accounts for the standing bow and stern

waves, whereas the narrowing of the bands at the sides indicates an increase of velocity and reduction of pressure, and accounts for the depression of water level, with which you are doubtless familiar, at the corresponding part of a ship.

I will now take a more striking case. If, instead of a circular body, we had a flat plate, the turbulent nature of the flow is evidently very great, as you will see from the view (Fig. 9), which is a photograph of the actual flow under these conditions, made visible by very fine air bubbles, and showing water at rest in the clear space behind the obstacle.

We can, however, take steps to reduce this turbulence, and you now see on the second screen the flow by means of apparatus which time does not permit me to describe, but which gives a slow and steady motion that it would be impossible to improve upon in actual conditions of practice, or even, I am inclined to think, by any experimental method. Instead of using air to

Fig. 9.

make this flow clear, we now allow colour to stream behind the plate, and you will see that the water still refuses to flow round to the back, and spreads on either side. We have so slow a velocity as not to induce vortex motion, but the inertia of the particles which strike the flat plate causes them to be deflected to either side, exactly as tennis-balls in striking against a wall obliquely. The sheet of water is so thick, that is to say, the parallel glass plates are so far apart, that they do not enable the viscosity of the water to act as a sufficient drag to prevent this taking place.

Mathematicians, however, predicted with absolute certainty that with stream-line motion, the water should flow round and meet at the back, a state of things that, however slow we make the motion in the present case, does not occur owing to the effect of inertia. They have drawn with equal confidence the lines along which this should take place. We could either effect this result with the experiment you have just seen, by using a much more viscous liquid, such as treacle, or, what comes to the same thing, bringing the two sheets of glass nearly close together; and the flow which you are now witnessing (Fig. 10) shows the result of doing this. The colour bands in front of the plate no longer mix at all with the general body of flow, or are unsteady, as was the case in the last experiment, but flow round the plate, and flow so steadily, that unless we jerk the flow of the colour bands, it is impossible to tell in which direction they are actually moving. It is interesting to note that where the divided central colour band re-unites is clearly shown in the illustration.

Whilst I have been dealing with the stream-lines of a perfect liquid, your minds will doubtless have turned to the lines along which magnetic and electrical forces appear to act. We are possibly further from realising the actual nature of these forces, than from a correct conception of the real nature of a liquid. We have long agreed to abandon the old ideas of the electrical and magnetic fluids flowing along these lines, and to substitute instead the idea that these lines represent merely the directions in which the forces act. Now we can easily see that this conception is quite a reasonable one, for in the case of the model it is not necessary to have the row of balls actually moving in order that the effect may be transmitted along the different lines they occupy. If I attempt to raise the plate upon which they rest, the pressure is instantly transmitted through

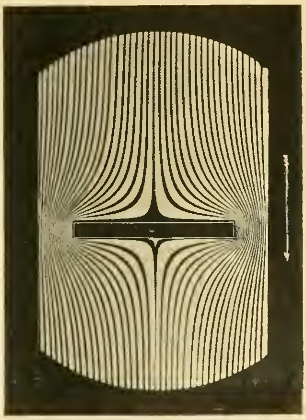


Fig. 10

the whole row to the top ball along each line, whatever curve the line may take. In the same way, you will remember that it was not necessary to have the colour bands actually in motion, for, though apparently free to move in any direction, they retain their form for a considerable time, and the path along which they would influence each other as soon as the tap is opened would be along those lines in which the liquid was flowing before it was brought to rest. Hence it is possible, with some suitable means, to cause a viscous liquid to reproduce exactly the lines of magnetic and electrical induction. In the case of magnetism and electricity, it is of course possible, by means of a small magnetic needle or a galvanometer, by exploring the whole surface through which magnetic induction or electrical flow is acting, to plot the lines of force for innumerable cases, where we can work in air or on the surface of the solid conductor.

But in this building it seems natural to take as an example the case first used by the great man to whom the conception of lines of magnetic force is due, for the first reference I have been able to find to such lines is in one of Faraday's earliest papers on the indication of electric currents ("Experimental Researches in Electricity," vol. i. p. 32), in which he says, "By magnetic curves I mean the lines of magnetic forces, however modified by the juxtaposition of poles, which would be depicted by iron

filings, or those to which a very small magnetic needle would form a tangent."

You are all familiar with the way in which iron filings set themselves when shaken over the north and south poles of a magnet. The magnetic lines are then nearly, but not quite, circular curves between the two poles. Now, the mathematics of the subject tells us that if the poles could be regarded as points, the lines of force between them would be perfect circles.

You are now looking at the colour bands, the edges—or indeed any portion—of which represent lines obtained by admitting coloured liquid from a series of small holes round a central small orifice, which admits clear liquid, and allows them to escape through another small orifice (called respectively in hydromechanics a *source* and *sink*), and I leave it to you to judge how far these curves deviate from the ideal form.

My assistant is now allowing the colour to flow, first steadily, and then in a series of impulses, and the latter gives us the conception of waves or impulses of magnetic force, though of course the magnetic transmission force would be instantaneous. Regarded as a liquid, it is here again clear how absolutely the truth of our views concerning the slower movement in the wider portion is verified by this experiment.

A last experiment shows the streams admitted, not from a source, but from a row of orifices in what corresponds to the slowest moving portion of the flow. The result is that the colour bands are much narrower, and although the circular forms of the curves are, as in the previous experiment, preserved, the lines are so fine at the point of exit, which, as before, corresponds to the South Pole, as to really approximate to ideal stream-lines.

The same method enables us to trace the lines of force through solid conductors, for, as long as we confine ourselves to two dimensions of space we may have *flat* conductors of any shape whatever. But it does something more, for by making the film rather deeper in some places than others, more particles arrange themselves there, and the lines of flow will naturally tend in the direction of the deeper portion. This will give the stream-lines identically the same shape as the magnetic or electrical curves which encounter in their paths a body of less resistance, for instance, a para-magnetic body.

If, on the other hand, at these points the film is made rather thinner, less particles will be able to dispose of themselves in the shallow portion of the film, and hence the lines of flow will be pushed away from this portion, giving us exactly the same forms as magnetic lines of force in a magnetic field in proximity to a diamagnetic body.

Here, again, mathematical methods have enabled lines of actual flow to be predicted, and you may compare the actual flow for the case of a cylindrical para-magnetic body, which was worked out some years ago.

You will doubtless not be inclined to question the practical value of stream-lines in the subject which we have just been considering, because, unlike the flow of an actual liquid, magnetic lines of force can never be themselves seen, and because there is no doubt as to the correspondence of the directions to the lines of a perfect liquid. It was the conception of these lines in the mind of Faraday, and more particularly their being cut by a moving wire, that enabled him to realise the nature of the subject more clearly than any other man at the time, and to do much towards the rapid development of electrical science and its practical applications.

When we come to consider the relation of the study of the motion of a perfect liquid with hydromechanics and naval architecture, it must be admitted that the matter is a difficult one. Probably one of the most perplexing things in engineering science is the absence of all apparent connection between higher treatises on hydrodynamics and the vast array of works on practical hydraulics. The natural connection between the treatises of mathematicians and experimental researches of engineers would appear to be obvious, but very little, if any, such connection exists in reality, and while at every step electrical applications owe much to the theories which are common to electricity and hydromechanics, we look in vain for such applications in connection with the actual flow of water.

Now the reason for this appears to be the immense difference between the flow of an actual liquid and that of a perfect one owing to the property of viscosity. A comparison of the various experiments which you have seen to some extent indicates this.

In the first place, let us consider for a moment some of the things which would happen if water were a perfect liquid. In such a case, a ship would experience a very different amount of resistance, because, although waves would be raised, owing to the reasons which we have already seen, the chief causes of resistance, viz. skin friction and eddying motion, would be entirely absent, and of course a submarine boat at a certain depth would experience no resistance at all, since the pressures fore and aft would be equal. On the other hand, there would be no waves raised by the action of the wind, and there would be no tidal flow, but to make up for this rivers would flow with incredible velocity, since there would be no retarding forces owing to the friction of the banks. But the rivers themselves would soon cease to flow because there would be no rainfall such as exists at present, since it is due to viscosity that the rain is distributed, instead of falling upon the earth in a solid mass when condensed. In a word, it may be said that the absence of viscosity in water would result in changes which it is impossible to realise.

We may now briefly try to consider the difference between practical hydraulics and the mathematical treatment of a perfect liquid. The earliest attempts to investigate in a scientific way the flow of water appears to have been made by a Roman engineer about 1800 years ago, an effort being made to find the law for the flow of water from an orifice. For more than 1500 years, however, even the simple principle of flow according to which the velocity of efflux varies as the square of the head, or what is the same thing, the height of surface above the orifice varies as the square of the velocity, remained unknown. Torricelli, who discovered this, did so as the result of observing that a jet of water rose nearly to the height of the surface of the body of water from which it issued, and concluded therefore that it obeyed the then recently discovered law of all falling bodies.

Though it was obvious that this law did not exactly hold, it was a long time before it was realised that it was the friction or viscosity of liquids that caused so marked a deviation from the simple theory. Since then problems in practical hydraulics, whether in connection with the flow in rivers or pipes, or the resistance of ships, have largely consisted in the determination of the amount of deviation from the foregoing simple law.

About one hundred years ago it was discovered that the resistance of friction varies nearly in accordance with the simple law of Torricelli, and also—although for a totally different reason—the resistances due to a sudden contraction or enlargement of cross-section of channel or to any sudden obstructions appear to follow nearly the same law. Now it is extremely convenient for reasons which will be understood by students of hydraulics to treat all kinds of resistance as following the same law, viz. square of velocity which the variation of head or height of surface has shown to do. But this is far from being exact, and an enormous amount of labour has consequently been expended in finding for all conceivable conditions in actual work tables of coefficients or empirical expressions which are required for calculations of various practical questions. Such data are continually being accumulated in connection with the flow of water in rivers and pipes for hydraulic motors and naval architecture. This is the practical side of the question.

On the other hand, eminent mathematicians, since the days of Newton and the discovery of the method of the calculus, have been pursuing the investigation of the behaviour of a perfect liquid. The mathematical methods, which I have already alluded to as being so wonderful, have, however, scarcely been brought to bear with any apparent result upon the behaviour of a viscous fluid. Indeed, the mathematician has not been really able to adopt the method of the practical investigator, and deal with useful forms of bodies such as those of actual ships, or of liquid moving through ordinary channels of varying section, even for the case of a perfect liquid, but he has had to take those cases, and they are very few indeed, that he has been able to discover which fit in with his mathematical powers of treatment.

This brief summary may possibly serve to indicate the nature of the difficulties which I have pointed out, and will show you the vast field there yet lies open for research in connection with the subject of hydromechanics, and the great reception which awaits the discovery of a theoretical method of completely dealing with viscous liquids, instead of having recourse as at present principally to empirical formula based on the simple law already alluded to.

We may, however, console ourselves with the thought, that in the application of the laws of motion themselves to *any* terrestrial matters, the friction of bodies must always be taken into account, and renders it necessary, that we should commence by studying the ideal conditions. In this as in other matters, the naval architect and engineer must always endeavour as far as possible to base their considerations and work upon the secure foundation of scientific knowledge, making allowances for disturbing causes, which then cease to be the source of perplexity and confusion. From this point of view, the study of the behaviour of a perfect liquid, even when no such form of matter appears to exist, has an interest for the practical man in spite of the deviation of actual liquids from such ideal conditions. If the truth must be told, it is such a deviation from the simple and ideal conditions that really constitute the work of a professional man, and it is only practical experience which, based upon sound technical knowledge, enables 50,000 tons of steel to be made to span the Firth of Forth, Niagara to be harnessed to do the work of 100,000 horses, or an *Oceanic* to be slid into the sea with as little misgiving as the launch of a fishing-boat.

I have, I am afraid, brought you only to the threshold of a vast subject, and in doing so have possibly employed reasoning of too elementary a kind. After all, I may plead that I have followed the dictum of Faraday, who said, "If assumptions must be made, it is better to assume as little as possible." If I have assumed too little knowledge on your part, it is because of the difficulties I have found in the subject myself. If I have left more obscure than I have been able to make clear, it is consoling to think how many centuries were required to discover even what is known at the present time, and we may well be forgiven if we cannot grasp at once results which represent the life-work of some of the greatest men.

## A PROBLEM IN AMERICAN ANTHROPOLOGY.[1]

WHILE engaged in writing the address that I am to read to you this evening, the sad news reached me of the death, on July 31, of our President of five years ago, Dr. D. G. Brinton. Although not unexpected, as his health had been failing since he was with us at the Boston meeting, where he took his always active part in the proceedings of Section H, and gave his wise advice in our general council, yet his death affects me deeply. I was writing on a subject we had often discussed in an earnest but friendly manner. He believed in an all-pervading psychological influence upon man's development, and claimed that American art and culture were autochthonous, and that all resemblances to other parts of the world were the results of corresponding stages in the development of man; while I claimed that there were too many root coincidences with variant branches to be fully accounted for without also admitting the contact of peoples. Feeling his influence while writing, I had hoped that he would be present to-night, for I am certain that no one would have more readily joined with me in urging a suspension of judgment, while giving free expression to opinions, until the facts have been worked over anew, and more knowledge attained.

Now that his eloquent tongue is silent and his gifted pen is still, I urge upon all who hear me to-night to read his two addresses before this Association—one as Vice-President of the Anthropological Section in 1887, published in our thirty-sixth volume of *Proceedings*, the other as retiring President in 1895, published in our forty-fourth volume. In these addresses he had in his usual forcible and comprehensive manner presented his views of American anthropological research and of the aims of anthropology.

Dr. Brinton was a man of great mental power and erudition. He was an extensive reader in many languages, and his retentive memory enabled him to quote readily from the works of others. He was a prolific writer, and an able critic of anthropological literature the world over. Doing little as a field archæologist himself, he kept informed of what was done by others through extensive travels and visits to museums. By his death American anthropology has suffered a serious loss, and a great scholar and earnest worker has been taken from our Association.

[1] Address delivered before the American Association for the Advancement of Science, at Columbus, Ohio, on August 21, by Prof. Frederic Ward Putnam, the retiring President of the Association.

In the year 1857 this Association met for the first time beyond the borders of the United States, thus establishing its claim to the name American in the broadest sense. Already a member of a year's standing, it was with feelings of youthful pride that I recorded my name and entered the meeting in the hospitable city of Montreal, and it was on this occasion that my mind was awakened to new interests which in after years led me from the study of animals to that of man.

On Sunday, August 16, while strolling along the side of Mount Royal, I noticed the point of a bivalve shell protruding from roots of grass. Wondering why such a shell should be there, and reaching to pick it up, I noticed on detaching the grass roots about it that there were many other whole and broken valves in close proximity—too many, I thought, and too near together, to have been brought by birds, and too far away from water to be the remnants of a musk-rat's dinner. Scratching away the grass and poking among the shells, I found a few bones of birds and fishes and small fragments of Indian pottery. Then it dawned upon me that there had been an Indian home in ancient times, and that these odds and ends were the refuse of the people—my first shell-heap or kitchen-midden, as I was to learn later. At the time this was to me simply the evidence of Indian occupation of the place in former times, as convincing as was the palisaded town of old Hochelaga to Cartier when he stood upon this same mountain side more than three centuries before.

At that meeting of the Association several papers were read, which, had there been a section of anthropology, would have led to discussions similar to those that have occurred during our recent meetings. Forty-two years later we are still disputing the evidence, furnished by craniology, by social institutions and by language, in relation to the unity or diversity of the existing American tribes and their predecessors on this continent.

Those were the days when the theory of the unity of all American peoples, except the Eskimo, as set forth by Morton in his "Crania Americana" (1839), was discussed by naturalists. The volumes by Nott and Gliddon, "Types of Mankind" (1854) and "Indigenous Races of the Earth" (1857), which contains Meigs' learned and instructive dissertation, "The Cranial Characteristics of the Races of Men," were the works that stirred equally the minds of naturalists and of theologians regarding the unity or diversity of man—a question that could not then be discussed with the equanimity with which it is now approached. The storm caused by Darwin's "Origin of Species" had not yet come to wash away old prejudices and clear the air for the calm discussion of theories and facts now permitted to all earnest investigators. Well do I remember, when, during those stormy years, a most worthy Bishop made a fervent appeal to his people to refrain from attending a meeting of the Association then being held in his city, on account of what he claimed to be the atheistic teachings of science. Yet ten years later this same venerable Bishop stood before us, in that very city, and invoked God's blessing upon the noble work of the searchers for truth.

At the meeting of 1857 one of our early presidents, the honoured Dana, read his paper entitled "Thoughts on Species," in which he described a species as "a specific amount or condition of concentrated force defined in the act or law of creation," and, applying this principle, determined the unity of man in the following words:—

"We have therefore reason to believe, from man's fertile intermixture, that he is one in species; and that all organic species are divine appointments which cannot be obliterated unless by annihilating the individuals representing the species."

Another paper was by Daniel Wilson, recently from Scotland, where six years before he had coined that most useful word "prehistoric," using the term in the title of his volume, "Prehistoric Annals of Scotland." In his paper Prof. (afterwards Sir Daniel Wilson controverted the statement of Morton that there was a single form of skull for all American peoples, north and south, always excepting the Eskimo. After referring to the views of Agassiz, as set forth in the volumes of Nott and Gliddon, he said, "Since the idea of the homogeneous physical characteristics of the whole aboriginal population of America, extending from Terra del Fuego to the Arctic circle, was first propounded by Dr. Morton, it has been accepted without question, and has more recently been made the basis of many widely comprehensive deductions. Philology and archæology have also been called in to sustain this doctrine of a special unity of the American race; and to prove that, notwithstanding

some partial deviations from the prevailing standard, the American Indian is essentially separate and peculiar; *a race distinct from all others*. The stronghold, however, of the argument for the essential oneness of the whole tribes and nations of the American continents is the supposed uniformity of physiological, and especially of physiognomical and cranial characteristics; an ethnical postulate which has not yet been called in question."

After a detailed discussion of a number of Indian crania from Canada and a comparison with those from other parts of America, as described by Morton, he makes the following statements:—"But, making full allowance for such external influences, it seems to me, after thus reviewing the evidence on which the assumed unity of the American race is formed, little less extravagant to affirm of Europe than of America, that the crania everywhere and at all periods have conformed, or even approximated, to one type."

"As an hypothesis, based on evidence accumulated in the "Crania Americana," the supposed homogeneity of the whole American aborigines was perhaps a justifiable one. But the evidence was totally insufficient for any such absolute and dogmatic induction as it has been made the basis of. With the exception of the ancient Peruvians, the comprehensive generalisations relative to the southern American continent strangely contrast with the narrow basis of the premises. With a greater amount of evidence in reference to the northern continent, the conclusions still go far beyond anything established by absolute proof; and the subsequent labours of Morton himself, and still more of some of his successors, seem to have been conducted on the principle of applying practically, and in all possible bearings, an established and indisputable scientific truth, instead of testing by further evidence a novel and ingenious hypothesis."

At the close of this instructive paper are the following words: "If these conclusions, deduced from an examination of Canadian crania, are borne out by the premises and confirmed by further investigation, this much at least may be affirmed: that a marked difference distinguishes the northern tribes, now or formerly occupying the Canadian area, in their cranial conformation, from that which pertains to the aborigines of Central America and the southern valley of the Mississippi; and in so far as the northern differ from the southern tribes, they approximate more or less, in the points of divergence, to the characteristics of the Esquimaux: that intermediate ethnic link between the Old and the New World, acknowledged by nearly all recent ethnologists to be physically a Mongol and Asiatic, if philologically an American."

The third paper of the meeting to which I shall refer was by another of our former presidents, the then well-known student of Indian institutions and the author of the "League of the Iroquois" (1851). In this paper, on "The Laws of Descent of the Iroquois," Morgan discusses the league as made up of five nations, each of which was subdivided into tribes, and he explains the law of marriage among the tribes, the family relationship and the descent in the female line, as essential to the maintenance of the whole system. He then says:—

"Now the institutions of all the aboriginal races of this continent have a family cast. They bear internal evidence of a common paternity, and point to a common origin, but remote, both as to time and place. That they all sprang from a common mind, and in their progressive development have still retained the impress of original elements, is abundantly verified. The Aztecs were thoroughly and essentially Indian. We have glimpses here and there at original institutions which suggest at once, by their similarity, kindred ones among the Iroquois and other Indian races of the present day. Their intellectual characteristics, and the predominant features of their social condition, are such as to leave no doubt upon this question; and we believe the results of modern research, upon this point, concur with this conclusion. Differences existed, it is true, but they were not radical. The Aztec civilisation simply exhibited a more advanced development of those primary ideas of civil and social life, which were common to the whole Indian family, and not their overthrow by the substitution of antagonistic institutions."

After calling attention to the fact that a similar condition exists among certain peoples of the Pacific Islands, he writes:—"Whether this code of descent came out of Asia or originated upon this continent is one of the questions incapable of proof; and it must rest, for its solution, upon the weight of evidence, or upon probable induction. Its existence among American races, whose languages are radically different, and without any traditional knowledge among them of its origin, indicates a very ancient introduction, and would seem to point to Asia as the birth-place of the system."

It would be interesting to follow the succeeding meetings of the Association, and note the recurring presentation of views which the quotations I have given show to have been most seriously discussed over a generation ago. An historical review of the literature of American anthropology during the present century would also be interesting in this connection. It is probable, however, that a review of this literature for the first half of the century would reveal the fact that the writers, with here and there a notable exception, were inclined to theorise upon insufficient data, and devoted little time to the accumulation of trustworthy facts. The presentation and discussion of carefully observed facts can almost be said to have begun with the second half of the century, and this is the only part of the subject that now commands serious attention.

A reference to the very latest *résumé* of this subject as presented in the "History of the New World called America," by Edward John Payne (vol. ii., Oxford, 1899), is instructive here. In this volume Mr. Payne admits the great antiquity and unity of the American tribes, which he considers came from Asia in pre-Glacial and Glacial times, when the north-western corner of America was connected with Asia, and when man "as yet was distinguished from the inferior animals only by some painful and strenuous form of articulate speech and the possession of rude stone weapons and implements, and a knowledge of the art of fire-kindling. Such, it may be supposed, were the conditions under which man inhabited both the old and the new world in the paleo-ethnic age. . . . Even when a geological change had separated them (the continents), some intercourse by sea was perhaps maintained—an intercourse which became less and less, until the American branch of humanity became practically an isolated race as America itself had become an isolated continent" (Preface).

Mr. Payne discusses the growth of the languages of America, the various social institutions and arts, and the migrations of these early savages over the continent, north and south, during the many centuries following, as one group after another grew in culture. He considers all culture of the people autochthonous. In writing upon the physical characters of the people, he says, "It may however be suggested that, as in the Old World, the earlier and the smaller tribes tend to dolichocephaly, while the better developed ones are rather brachycephalous, a conclusion indicating that the varying proportions of the skull should be taken less as original evidence of race than as evidence of physical improvement."

This volume by Mr. Payne is replete with similar statements of facts and theories, and shows how difficult it is for us to understand the complications of the subject before us. It cannot be denied that, taking into consideration the number of authors who have written on this subject, Mr. Payne is well supported in his theory of the autochthonous origin of all American languages, institutions and arts; but the question arises, Has not the old theory of Morton, the industrious and painstaking pioneer of American craniology, been the underlying cause of this, and have not the facts been misinterpreted? At the time of Morton, the accepted belief in the unity and universal brotherhood of man was about to be assailed, and it seems, as we now look back upon those times of exciting and passionate discussions, that Morton may have been influenced by the new theory that was so soon to become prominent, namely, that there were several distinct creations of species of the genus *Homo*, and that each continent or great area had its own distinct fauna and flora. Certainly Morton ventured to make a specific statement from a collection of crania which would now be regarded as too limited to furnish true results.

The anthropologist of to-day would hardly venture to do more than to make the most general statement of the characters of any race or people from the examination of a single skull, although after the study of a large number of skulls from a single tribe or special locality he would probably be able to select one that was distinctly characteristic of the special tribe or group to which it pertained.

Relatively long and narrow heads and broad and short heads occur almost everywhere in greater or less proportion. In determining the physical characters of a people, so far as this can be done from a study of crania, the index of the height of

the skull is quite as important as that of its breadth. These indices simply give us the ready means of expressing by figures the relative height and breadth of one skull in comparison with another—a small part of what the zoologist would consider in describing, for instance, the skulls of different species of the genus *Canis*. So in our craniological studies we should determine the relative position, shape and proportions of the different elements of the skull. In fact we should approach the study of human crania with the methods of the zoologist, and should use tables of figures only so far as such tables give us the means of making exact comparisons. Here again are the anthropologists at a disadvantage, inasmuch as it is only very recently that we are approaching a standard of uniformity in these expressions. It is now more than ever essential that anthropologists should agree upon a method of expressing certain observed facts in somatology, so that the conscientious labours of an investigator, who has a special opportunity for working upon one group of man, may be made available for comparison by investigators of other groups.

Probably the old method, still largely in vogue, of stating averages is responsible for many wrong deductions. If we take one hundred or more skulls of any people, we shall find that the two extremes of the series differ to a considerable extent from those which naturally fall into the centre of the series. These extremes in the hands of a zoologist would be considered the sub-varieties of the central group or variety. So in anthropology, we should take the central group of the series as furnishing the true characters of the particular variety or group of man under consideration, and should regard the extremes as those which have been modified by various causes. It may be said that this central group is defined by stating the mean of all the characters; but this is hardly the case, for by giving the mean of all we include such extraneous characters as may have been derived by admixture or from abnormal conditions.

The many differing characteristics exhibited in a large collection of crania, brought together from various portions of America, north and south, it seems to me, are reducible to several great groups which may be generally classed as the Eskimo type, the northern and central or so-called Indian type, the north-western brachycephalic type, the south-western dolichocephalic type, the Toltecan brachycephalic type, and the Antillean type, with probably the ancient Brazilian, the Fuegian and the pre-Inca types of South America. Each of these types is found in its purity in a certain limited region, while in other regions it is more or less modified by admixture. Thus the Toltecan or ancient Mexican type (which, united with the Peruvian, was separated as the Toltecan family even by Morton) occurs, more or less modified by admixture, in the ancient and modern pueblos and in the ancient earth-works of our central and southern valleys. In Peru, more in modern than in ancient times, there is an admixture of two principal types. At the north of the continent we again find certain traits that possibly indicate a mixture of the Eskimo with the early coast peoples both on the Pacific and on the Atlantic sides of the continent. The North-central Indian type seems to have extended across the Continent and to have branched in all directions, while a similar but not so extensive branching, north-east and south, seems to have been the course of the Toltecan type.

This is not theorising upon the same facts from which Morton drew the conclusion that all these types were really one and the same. Since Morton's time we have had large collections of crania for study, and the crania have been correlated with other parts of the skeleton and with the arts and institutions of the various peoples.

Although these relations have been differently interpreted by many anthropologists who have treated the subject, yet to me they seem to indicate that the American continent has been peopled at different times and from various sources; that the great lapse of time since the different immigrants reached the continent has in many places brought about an admixture of the several stocks and modified to a greater or less extent the arts and customs of all, while natural environment has had a great influence upon the ethnic development of each group. Furthermore, contact of one group with another has done much to unify certain customs, while "survivals" have played an active part in the adoption and perpetuation of arts and customs not native to the people by whom they are preserved.

The Inca civilisation, a forcible one coming from the north, encroached upon that of the earlier people of the vicinity of Lake Titicaca, whose arts and customs were to a considerable extent adopted by the invaders. It is of interest here to note the resemblance of the older Andean art with that of the early Mediterranean, to which it seemingly has a closer resemblance than to any art on the American continent. Can it be that we have here an æsthetic survival among this early people, and could they have come across the Atlantic from that Eurafric region which has been the birthplace of many nations? Or is this simply one of those psychical coincidences, as some writers would have us believe? The customs and beliefs of the Incas point to a northern origin, and have so many resemblances to those of the ancient Mexicans, as hardly to admit of a doubt that in early times there was a close relation between these two widely separated centres of ancient American culture. But how did that pre-Inca people reach the Lake region? Is it not probable that some phase of this ancient culture may have reached the Andes from northern Africa? Let us consider this question in relation to the islands of the Atlantic. The Canary Islands, as well as the West Indies, had long been peopled when first known to history; the Caribs were on the northern coast of South America as well as on the islands; and, in the time of Columbus, native trading boats came from Yucatan to Cuba. We thus have evidence of the early navigation of both sides of the Atlantic, and certainly the ocean between could easily have been crossed.

One of the most interesting as well as most puzzling of the many phases of American archæology is the remarkable development of the art of the brachycephalic peoples, extending from northern Mexico, north-eastward to the Mississippi and Ohio valleys, then disappearing gradually as we approach the Alleghenies and, further south, the Atlantic coast, also spreading southward from Mexico to Honduras, and changing and vanishing in South America. Unquestionably of very great antiquity, this art, developed in the neolithic period of culture, reached to the age of metals, and had already begun to decline at the time of the Spanish conquest. How this remarkable development came to exist amid its different environments, we cannot yet fully understand; but the question arises, Was it of autochthonous origin, and due to the particular period in man's development, or was it a previously existing phase modified by new environment? For the present this question should be held in abeyance. To declare that the resemblance of this art to both Asiatic and Egyptian art is simply a proof of the psychical unity of man is assuming too much, and is cutting off all further consideration of the subject.

The active field and museum archæologist or ethnologist who knows and maintains the associations of specimens as found, and who arranges them in their geographical sequence, becomes intimately in touch with man's work under different phases of existence.

Fully realising that the natural working of the human mind under similar conditions will to a certain extent give uniform results, he has before him so many instances of the transmission of arts, symbolic expressions, customs, beliefs, myths and languages, that he is forced to consider the lines of contact and migration of peoples as well as their psychical resemblances.

It must be admitted that there are important considerations, both physical and mental, that seem to prove a close affinity between the brown type of Eastern Asia and the ancient Mexicans. Admitting this affinity, the question arises, Can there have been a migration eastward across the Pacific in neolithic times, or should we look for this brown type as originating in the Eurafric region and passing on to Asia from America? This latter theory cannot be considered as a baseless suggestion when the views of several distinguished anthropologists are given the consideration due to them. On the other hand, the theory of an early migration from Asia to America may also be applied to neolithic time.

However this may have been, what interests us more at this moment, and in this part of America, is the so-called "mound-builder" of the Ohio valley. Let us first clear away the mist which has so long prevented an understanding of this subject by discarding the term "mound-builder." Many peoples in America as well as on other continents have built mounds over their dead, or to mark important sites and great events. It is thus evident that a term so generally applied is of no value as a scientific designation. In North America the term has been applied even to refuse piles; the kitchen-middens or shell-heaps which are so numerous along our coasts and rivers have been classed as the work of the "mound-builder." Many of these shell-heaps are

of great antiquity, and we know that they are formed of the refuse gathered on the sites of the early peoples. From the time of these very early deposits to the present such refuse piles have been made, and many of the sites were reoccupied, sometimes even by a different people. These shell-heaps therefore cannot be regarded as the work of one people. The same may be said in regard to the mounds of earth and of stone so widely distributed over the country. Many of these are of great antiquity, while others were made within the historic period and even during the first half of the present century. Some mounds cover large collections of human bones, others are monuments over the graves of noted chiefs; others are in the form of effigies of animals and of man; and, in the south, mounds were in use in early historic times as the sites of ceremonial or other important buildings. Thus it will be seen that the earth-mounds, like the shell-mounds, were made by many peoples and at various times.

There are, however, many groups of earth-works which, although usually classed as mounds, are of an entirely different order of structure and must be considered by themselves. To this class belong the great embankments, often in the form of squares, octagons, ovals and circles, and the fortifications and singular structures on hills and plateaus which are in marked contrast to the ordinary conical mounds. Such are the Newark, Liberty, Highbank and Marietta groups of earth-works, the Turner group, the Clark or Hopewell group, and many others in Ohio and in the regions generally south and west of these great central settlements; also the Cahokia Mound opposite St Louis, the Serpent Mound of Adams County, the great embankments known as Fort Ancient, which you are to visit within a few days, the truly wonderful work of stone known as Fort Hill in Highland County, and the strange and puzzling walls of stone and cinder near Foster's station.

So far as these older earth-works have been carefully investigated they have proved to be of very considerable antiquity. This is shown by the formation of a foot or more of vegetable humus upon their steep sides; by the forest growth upon them, which is often of primeval character; and by the probability that many of these works, covering hundreds of acres, were planned and built upon the river terraces before the growth of the virgin forest.

If all mounds of shell, earth or stone, fortifications on hills, or places of religious and ceremonial rites, are classed, irrespective of their structure, contents, or time of formation, as the work of one people, and that people is designated "the American Indian" or the "American Race," and considered to be the only people ever inhabiting America, North and South, we are simply repeating what was done by Morton in relation to the crania of America—not giving fair consideration to differences while over-estimating resemblances. The effort to affirm that all the various peoples of America are of one race has this very year come up anew in the proposition to provide "a name which shall be brief and expressive," and at the same time shall fasten upon us the theory of unity—notwithstanding the facts show diversity—of race.

Let us now return to the builders of the older earth-works, and consider the possibility of their having been an offshoot of the ancient Mexicans. Of the crania from the most ancient earth-works we as yet know so little that we can only say that their affinities are with the Toltecan type; but of the character of the art, and particularly the symbolism expressing the religious thought of the people, we can find the meaning only by turning to ancient Mexico. What northern or eastern Indian ever made or can understand the meaning of such sculptures or such incised designs as have been found in several of the ancient ceremonial mounds connected with the great earth-works? What Indian tribe has ever made similar carved designs on human and other bones, or such singular figures, cut out of copper and mica, as were found in the Turner and Hopewell groups? or such symbolic animal forms, elaborately carved in stone, and such perfect terra-cotta figures of men and women as were found on the sacrificial altars of the Turner group? What meaning can be given to the Cincinnati Tablet, or to the designs on copper plates and shell discs from some of the southern and western burial and ceremonial mounds? I think we shall search in vain for the meaning of these many objects in the north or east, or for much that resembles them in the burial-places of those regions. On the other hand, most of these become intelligible when we compare the designs and symbols with those of the ancient Mexican and Central American peoples. The Cincinnati Tablet, which has been under discussion for over half a century, can be interpreted and its dual serpent characters understood by comparing it with the great double image known in Mexico as the Goddess of Death and the God of War; the elaborately complicated designs on copper plates, on shell discs, on human bones, and on the wing bones of the eagle, can in many instances be interpreted by comparison with Mexican carvings and with Mexican modes of symbolic expression of sacred objects and religious ideas. The symbolic animals carved on bone or in stone, and the perfection of the terra-cotta figures, point to the same source for the origin of the art.

In connection with the art of the builders, let us consider the earth structures themselves. The great mound at Cahokia, with its several platforms, is only a reduction of its prototype at Chalula. The fortified hills have their counterparts in Mexico. The serpent effigy is the symbolic serpent of Mexico and Central America. The practice of cremation and the existence of altars for ceremonial sacrifices strongly suggest ancient Mexican rites. We must also recall that we have a connecting link in the ancient pueblos of our own south-west, and that there is some evidence that in our Southern States, in comparatively recent times, there were a few remnants of this old people. It seems to me, therefore, that we must regard the culture of the builders of the ancient earth-works as one and the same with that of ancient Mexico, although modified by environment.

Our northern and eastern tribes came in contact with this people when they pushed their way southward and westward, and many arts and customs were doubtless adopted by the invaders as shown by customs still lingering among some of our Indian tribes. It is this absorption and admixture of the peoples that has in the course of thousands of years brought all our American peoples into a certain conformity. This does not, however, prove a unity of race.

It is convenient to group the living tribes by their languages. The existence of more than a hundred and fifty different languages in America, however, does not prove a common origin, but rather a diversity of origin as well as a great antiquity of man in America.

That man was on the American continent in quaternary times, and possibly still earlier, seems to me as certain as that he was on the Old World during the same period. The Calaveras skull, that bone of contention, is not the only evidence of his early occupation of the Pacific coast. On the Atlantic side, the recent extensive explorations of the glacial and immediately following deposits at Trenton, are confirmatory of the occupation of the Delaware valley during the closing centuries of the glacial period, and possibly also of the inter-glacial time. The discoveries in Ohio, in Florida, and in various parts of Central and South America, all go to prove man's antiquity in America. Admitting the great antiquity of one or more of the early groups of man on the continent, and that he spread widely over it while in the palæolithic and early neolithic stages of culture, I cannot see any reason for doubting that there were also later accessions during neolithic times, and even when social institutions were well advanced. While these culture epochs mark certain phases in the development of a people, they cannot be considered as marking special periods of time. In America we certainly do not find that correlation with the Old World periods which we are so wont to take for granted.

We have now reached the epoch of careful and thorough exploration and of conscientious arrangement of collections in our scientific museums. It is no longer considered sacrilegious to exhibit skulls, skeletons and mummies in connection with the works of the same peoples. Museums devoted primarily to the education of the public in the æsthetic arts are clearing their cases of heterogeneous collections of ethnological and archæological objects. Museums of natural history are being arranged to show the history and distribution of animal and vegetable life and the structure of the earth itself. Anthropological museums should be similarly arranged, and, with certain gaps which every curator hopes to fill, they should show the life and history of man. To this end, the conscientious curator will avoid the expression of special theories, and will endeavour to present the true status of each tribe or group of man in the past and in the present, so far as the material at his command permits. A strictly geographical arrangement is therefore the primary principle which should govern the exhibition of anthropological collections. A special exhibit may be made in order to illustrate certain methods by which man in different regions has attained similar results, either by contact

or by natural means. Another exhibit may be for the purpose of showing the distribution of corresponding implements over different geographical areas. These and similar special exhibits are instructive, and under proper restrictions should be made; but unless the design of each exhibit is clearly explained, the average visitor to a museum will be confused and misled, for such objects so grouped convey a different impression than when exhibited with their associated objects in proper geographical sequence.

The anthropology of America is now being investigated, and the results are being made known through museums and publications as never before.

The thoroughly equipped Jesup North Pacific Expedition, with well-trained anthropologists in charge, was organised for the purpose of obtaining material, both ethnological and archæological, for a comparative study of the peoples of the northern parts of America and Asia. Although only in the third year of its active field work, it has already furnished most important results and provided a mass of invaluable authentic material.

The Hyde Expedition, planned for long-continued research in the archæology and ethnology of the south-west—a successor in regard to its objects to the important Hemenway Expedition —is annually adding chapters to the story of the peoples of the ancient pueblos.

The results of the extensive explorations by Moore of the mounds of the southern Atlantic coast are being published in a series of important monographs.

The Pepper-Hurst Expedition to the Florida Keys has given information of remarkable interest and importance from a rich archæological field before unknown.

The United States Government, through the Bureau of Ethnology of the Smithsonian Institution, has given official and liberal support to archæological and ethnological investigations in America.

The constantly increasing patronage, by wealthy men and women, of archæological research at home, as well as in foreign lands, is most encouraging.

The explorations in Mexico and in Central and South America, the publication in facsimile of the ancient Mexican and Maya codices, the reproduction by casts of the important American sculptures and hieroglyphic tablets, all have been made possible by earnest students and generous patrons of American research.

The numerous expeditions, explorations and publications of the Smithsonian Institution and of the museums of Washington, Chicago, Philadelphia, New York and Cambridge, are providing the student of to-day with a vast amount of authentic material for research in American and comparative anthropology.

The Archæological Institute of America, the American Folk Lore Society, and the archæological and anthropological societies and clubs, in active operation in various parts of the country, together with the several journals devoted to different branches of anthropology, give evidence of widespread interest.

Universities are establishing special courses in anthropology, and teachers and investigators are being trained. Officers of anthropological museums are preparing men to be field workers and museum assistants.

The public need no longer be deceived by accounts of giants and other wonderful discoveries. The wares of the mercenary collector are at a discount, since unauthentic material is considered worthless. Anthropology is now a well-established science. It is required of those who follow any of its branches to do so in seriousness and with scientific methods.

With all this wealth of materials and opportunities there can be no doubt that anthropologists will in time be able to solve that problem which for the past half-century has been discussed in this Association—the problem of the unity or diversity of prehistoric man in America.

## *UNIVERSITY AND EDUCATIONAL INTELLIGENCE.*

A LARGE amount of information referring to examining authorities and educational institutions in this country appears in the students' numbers issued by several of our contemporaries. The *British Medical Journal* of August 26 and the *Lancet* of September 1 are almost entirely devoted to descriptions of the various methods by which a student may become a fully qualified practitioner. The *Chemical News* of September 1 gives a list of British universities and the chief colleges, technical schools, and institutes. The *Chemist and Druggist* of September 2 contains particulars of the educational requirements for qualification in pharmacy, medicine, dentistry, and veterinary surgery.

SOME time ago a departmental committee was formed to report as to the buildings and site of a proposed new Royal College of Science for Ireland. It is now announced by the *Times* that the Government have arranged to acquire the whole of the house property and ground occupying the site recommended by the departmental committee in addition to the buildings mentioned in the report. The total area thus acquired amounts to over 50,000 superficial feet, and the new buildings will have a frontage both on Kildare Place and Upper Merrion Street, and will, as the report recommends, be in immediate connection with the Museum of Science and Art.

THE West Ham Municipal Technical Institute is one of the newest of the London Polytechnics, and the first session of full work will commence towards the end of the present month. The Institute has been built by the Council of the County Borough of West Ham at a cost of 45,000*l*., and a further sum of 15,000*l*. has been spent upon the equipment and fittings. Under the direction of the principal, Mr. Albert E. Briscoe, an admirable programme of classes has been prepared; and a glance through it shows that provision has been made for theoretical and practical instruction in most branches of pure and applied science and art. Every effort appears to be made to encourage students to use wisely the educational facilities which the Institute affords. As an instance of the excellent policy which is being pursued, the following extract from the "Program" just published is noteworthy:—"Trade students are urged not to make the mistake of joining trade classes only. If any thorough knowledge of the principles of their trade is to be gained, they must possess an acquaintance with elementary science, and have some knowledge of arithmetic, mensuration, and elementary mathematics. For example, very little progress can be made in building or engineering drawing without some knowledge of elementary geometry; plumbing and engineering students will not obtain a clear grasp of their work unless they have some knowledge of elementary physics, of arithmetic, and elementary mathematics. They are further advised to pursue thoroughly the study of one or two subjects, and not waste their energies by attempting to cover the whole ground of science, and so obtain only a smattering of knowledge. The advantage of systematic study in science lies not so much in the number of facts learnt as in the training in habits of accuracy of work and thought, that enables men to attack new problems as they present themselves in a manner likely to ensure their successful solution." Much may be hoped from a Polytechnic in which such sound educational principles are impressed upon the students.

## *SCIENTIFIC SERIALS.*

*American Journal of Science*, August.—Rotatory polarisation of light in media subjected to torsion, by A. W. Ewell. The difficulties encountered in the choice of a proper material for experiment are very great, as already pointed out by Verdet and Wertheim. The author found a satisfactory combination in jelly supported in rubber tubes, and the observations with jelly, corroborated by a few observations with glass, demonstrate that torsion of a cylinder produces the rotatory polarisation of a ray proceeding in a direction parallel to the axis of the cylinder, the rotation of the plane of polarisation being opposite to the twist, and a function of the twist of degree higher than the first.—Studies in the Cyperaceæ xi., by T. Holm. This article deals with the abnormal development of some specimens of *Carex stipata*, Muhl., caused by *Livia vernalis*, Fitch.—The constitution of tourmaline, by F. W. Clarke. The author discusses the respective merits of Penfield and Foote's formula for tourmalines, regarded as salts of the alumino-borosilicic acid, $H_{11}Al_3B_2Si_4O_{21}$, and his own derivation from the similar acid, $H_{14}Al_5B_3Si_6O_{31}$, with all of the hydrogen atoms replaceable by bases. He retains the general form of his own formula, but suggests that certain irreducible differences of constitution may be due to the fact that there exists a series of borosilicic acids.—Determination of tellurous acid in the presence of haloid salts, by F. A. Gooch and C. A. Peters. In the estimation of tellurous acid by oxidation with excess of potassium permanganate, no correction

is necessary when the tellurous oxide is dissolved originally in an alkaline hydroxide and the solution made acid only to a limited degree with sulphuric acid.—An iodometric method for the estimation of boric acid, by L. C. Jones. The method is based upon the employment of mannite and of a mixture of potassium iodide and iodate.—A method for the detection and separation of dextro- and lævo-rotatory crystals, by D. Albert Kreider. The method is based upon the use of a kind of polarimeter with a wide field of vision of a uniform colour, adjusted in such a manner that any small crystal instantly reveals the sense of its rotation by its colour when brought into the field.—New meteoric iron found near the Tombigbee River, Choctaw and Sumter Counties, Alabama, by W. M. Foote. The fall consisted of a series of pieces found in almost a straight line north and south along a nine-mile stretch of the public road.—Orthoclase crystals from Shinano, Japan, by C. Iwasaki. Describes four different classes of orthoclase, mostly twinned after the Baveno type.

*Wiedemann's Annalen der Physik und Chemie*, No. 7.—Smallest thickness of liquid films, by K. T. Fischer. The author brings the widely varying results of various observers into approximate harmony by supposing that when a drop of oil is placed on a surface of pure water, a "precursory film" spreads over the water first, and is followed at a slower rate by the film studied by Sohncke and others. For his own experiments the author used a pure mercury surface, which he found to possess various advantages.—Wehnelt's electrolytic interrupter, by A. Voller and B. Walter. The hydrogen lines are very pronounced in the spectrum of the Wehnelt spark. Intense and pure metallic spectra may be obtained by choosing the metal in question as the substance of the anode. The hydrogen lines do not interfere, but serve as lines of reference.—Kathode rays, by A. Wehnelt. The author distinguishes between two classes of kathode ray shadows. One class is produced by rays emerging from the kathode normal to its surface and crossing each other at a focus in the case of a curved kathode. The other class consists always of upright shadows, thrown by rays travelling in a direction parallel to the axis of the tube.—Cause of the change in the conductivity of a metallic powder, by T. Sundorph. The author proves the formation of connecting chains of particles in a coherer by sparking across the gap between two metallic blocks on a glass plate, with a layer of nickel or iron filings between them.—A new vacuum discharge phenomenon, by L. Fomm. A vacuum tube is surrounded by wire rings at its two ends. At a certain exhaustion blue rings appear, concentric with the wire rings, and enclosing patches of positive light, which gradually disappear until the blue light fills the whole cross section. As the pressure diminishes still further the blue light detaches itself from the glass walls, and expands longitudinally, forming a greenish-blue beam which proceeds in the direction of the other ring, and shows all the properties of kathode rays.—Some experiments with Wehnelt's interrupter, by E. Lecher. The author describes some beautiful phenomena obtained by bringing the secondary spark discharge of a Wehnelt interrupter into a magnetic field. The secondary current is unidirectional, and is therefore deflected in a constant direction. When the discharge takes place between a circle of wire and a disc mounted in its plane, and concentric with it, the discharge consists of curved spokes of light which rotate rapidly, in a sense governed by the polarity of the magnet. The discharges form a kind of fire-wheel as displayed in pyrotechnics.

## SOCIETIES AND ACADEMIES.

### PARIS.

**Academy of Sciences**, August 28.—M. Michel Lévy in the chair.—On the general form of the equations of dynamics, by M. P. Appell. The advantage of the form of equation described is that it allows the use of parameters which are not true coordinates, but are connected with the coordinates by non-integrable differential relations. The method is of especial service in problems of rolling.—On the velocity of detonation of acetylene, by MM. Berthelot and Le Chatelier. Acetylene was detonated in a glass tube by caps of mercury fulminate or chlorate powder, care being taken to have the detonator as small as possible, as it was found that irregularities were introduced if the detonator used was too violent. The acetylene was contained in horizontal glass tubes, under pressures varying from 5 to 36 atmospheres, and the velocity was registered photographically upon a falling sensitised plate, the light emitted by the explosion itself being sufficient for the purpose. As the flame moved further from the source of explosion the velocity continually increased, the tube generally breaking before the speed became uniform. Even when the conditions of inflammation and pressure are apparently precisely identical in two succeeding experiments, discordant results were sometimes obtained for the increase of velocity of the flame along the tube. The results show that the propagation of the detonation of acetylene is produced with a velocity which increases with the pressure from 1000 metres per second at 5 atmospheres pressure to 1600 metres per second at 30 atmospheres.—M. Henri Moissan communicated to the Academy a letter he had received from Prof. Dewar, of London, in which details were given of the solidification of hydrogen. Solid hydrogen melts at 16° absolute (−257°), and at this temperature helium is liquefied under a pressure of 8 atmospheres.—Discovery of a new planet at the Observatory of Paris, by M. Jean Mascart.—The Perseids in 1899, by M. C. Flammarion. The tabulated list is accompanied by a chart showing the point of origin and direction of motion of the Perseids in 1899.—On beats given by vibrating strings, by M. C. Maltézos. The ordinary equation for a thin elastic string giving the relation between the number of vibrations, tension, section, and length of string gives no explanation of the phenomenon of beats. If the rigidity of the string be taken into account, the author theoretically deduces an expression for the number of vibrations from which can be deduced that the number of beats is proportional to the square root of the area of section, inversely proportional to the cube of the length, and inversely proportional to the square root of the tension. The last conclusion has been verified experimentally, but instead of the number of beats being inversely proportional to the cube of the length of the strength, it is nearly inversely as the length simply. Hence it is impossible from rigidity alone to explain all the phenomena of beats in vibrating strings.

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THURSDAY, SEPTEMBER 14, 1899.

## *THE CORRESPONDENCE OF HUYGENS.*

*Œuvres complètes de Christiaan Huygens publiées par la Société Hollandaise des Sciences.* Tome Huitième. Correspondance 1676–1684. Pp. 629. 4to. (La Haye: Nijhoff, 1899).

EXACTLY a year after the seventh volume of Huygens' correspondence the eighth one has made its appearance. As it embraces nine years, and Huygens only lived ten years longer, we may expect that the ninth volume will be the last one devoted to his correspondence. The objection which we made a year ago to the many comparatively uninteresting private letters which have contributed so much to the huge extent to which this collection has grown, applies equally to the present volume. No doubt Huygens was very glad to get the pleasant, gossiping letters from his sister Susanna, who kept him up to what was going on in Holland during his stay in Paris, but posterity will hardly be equally grateful to the far too conscientious editors who have considered it a duty to insert them among Huygens' "Œuvres complètes." One feels momentarily almost kindly disposed towards the niece of Peiresc, who ruthlessly destroyed ten thousand letters found after him.

Having suffered from ill-health for some months, Huygens left Paris for the Hague in the summer of 1676. In the autumn of the following year he wrote to Colbert to apologise for not coming back that winter owing to his health, but it appears from a letter to his brother Constantin that this was a mere excuse. To his absence from Paris at this particular time we owe some very interesting letters, exchanged between him and Roemer about the latter's discovery of the gradual propagation of light. Huygens had to return to Paris in the summer of 1678, as he did not wish to lose his French pension, but in 1681 he bade a final farewell to Paris and established himself in his native country. It has been generally supposed that he and Roemer (who had left the French capital a few months before him) were induced to do so by the feeling that Protestants were about to have a bad time in France, though as a matter of fact the edict of Nantes was not repealed till four years later. No doubt this feeling may have had something to do with their departure, but we learn from his correspondence that Huygens did not debar himself from returning, but kept a door open by writing from time to time to Colbert, and after his death to Louvois, regretting that the necessity of being near skilful workmen prevented him from returning yet, and expressing the hope that his pension might not be finally withdrawn. Doubtless he spoke his mind more honestly when he wrote to Constantin (September 1682) that he had no intention of living in France, partly on account of the three illnesses he had suffered from there, "and also for other reasons," but that he wanted to try to get some part of his pension without living in France. From the very last letter in the volume we see that he was in December 1684 still pegging away at Louvois, but the Minister of War of Louis XIV. no doubt considered that money was too scarce to be spent on a foreign philosopher.

The skilful workmen, whom Huygens wanted in 1681 were required for the completion of his planetary machine, by which he claimed to represent the motions in the solar system with considerable accuracy. Huygens was very proud of the performance of this machine, which is still preserved at the Leiden Observatory, and in letters to Colbert and others he repeatedly lays stress on its superiority to the machine for the same purpose constructed by Roemer, which is also still in existence, in the "Round Tower" at Copenhagen, on the top of which the observatory was formerly situated. While working at this machine Huygens also wrote to Paris that he was engaged in the perfection of time-keepers for finding the longitude, and that he did so at the instance of the East India Company, but we hear nothing further about this matter. After his return to Holland he and Constantin resumed their investigations on the best methods of polishing lenses for telescopes, and in a number of letters they exchanged their ideas as to the proper construction of polishing machines, &c. In 1684 Christian Huygens published his "Astroscopia compendiaria," in which he described his method of using very long telescopes without tubes, keeping the eye-piece in the optical axis of the object-glass by means of a long string which connected two rods attached one to each. In a letter dated June 5, 1684, J. D. Cassini makes the very remarkable suggestion that the object-glass might be moved by a monster clock moving in the plane of the equator, on which for the hand was substituted a perpendicular plane to which the lens might be attached according to the declination of the star. We believe this to be the earliest suggestion of an equatorial moved by clockwork. On the other hand, Perrault, a month later, sent Huygens a design of a horizontal telescope into which the light from the star was thrown by a mirror kept in the proper position by an assistant, who pointed to the star with a small altazimuth tube connected with the mirror by a system of pulleys. He also sent a similar design by a certain Boffat. It is interesting to see that the horizontal telescope has been proposed so long ago.

During the period (1676–84) covered by the present volume several discoveries of the highest importance were given to the world, especially the discovery of the differential calculus by Leibnitz, but the communications exchanged between him and Huygens on this subject have already been printed in the collections of Uylenbroek and Gerhardt. Quite new, on the other hand, are the letters on Roemer's discovery of the gradual propagation of light, only the two first of which have been printed before (in Horrebow's "Opera mathematico-physica," T. iii. pp. 126–127, apparently not noticed by the editors). In reply to an inquiry from Huygens, who had seen in the *Phil. Trans.*, No. 136, a short account of Roemer's paper (laid before the Academy on November 22, 1676), Roemer informed him, under date September 30, 1677, that Picard acknowledged the reality of the discovery, but that Cassini did not, as only the first satellite of Jupiter showed the phenomenon. Roemer explained this by pointing out that the occultations of the outer satellites were less frequent, the moments of their occultations less sharply observable owing to the

slower motion and to their generally entering the shadow more obliquely; their inclinations and nodes were less accurately known, while it was well known that the motions of the outer satellites differed in a very irregular manner from Cassini's tables by amounts much larger than that dealt with in the case of the first satellite. The deviation in question was neither a function of the anomaly of Jupiter nor of that of the earth, nor of the configuration of the satellites, but solely of the distance from the earth. Writing to Colbert shortly afterwards, Huygens calls the discovery a most important one, in the confirmation of which the Royal Observatory would be worthily employed, and he adds that he was all the more pleased, as he had himself already, by means of this hypothesis, demonstrated the laws of the double refraction in Iceland spar. To Roemer he wrote that Cassini's objection did not trouble him much, as long as there were not better ephemerides of the outer satellites available. He doubted that observations of the surface-markings of Jupiter would be of any use in this inquiry, as they could not be accurate enough; but this Roemer did not acknowledge, since the time of passage of a spot across the central meridian could be fixed within two minutes. In a subsequent letter and in a communication to the Academy (which does not seem to have been printed before), Roemer proudly gives observations of a spot of September and December 1677, the comparison of which with an assumed value of the period of rotation seemed to exhibit the phenomenon beautifully. Of much greater interest is a remark made by Roemer in a letter dated December 30, 1677, in which he points out that the motion of the earth must affect the apparent direction of the path of light! In Cartesian language, he expresses this by saying that the circular motion of the terrestrial vortex must produce a curvature of the path, and he ingeniously suggests that the amount of this deflection might be determined by selecting two stars in the zodiac, nearly opposite each other, and observing their angular distance apart, first when one was at its heliacal rising, and again four or five months later when the other approached its heliacal setting. The difference would be four times the amount of the deflection, or, as we should say, four times the constant of aberration. It is very remarkable that Picard, Roemer's teacher and friend, should have discovered the changes in the place of the pole-star due to aberration (and also those due to nutation, though not the laws which regulate either—see his "Voyage d'Uranibourg," article viii.), while Roemer logically concluded from his discovery of the velocity of light that there ought to be aberration of light. But it was reserved for Bradley to publish both the laws and the theory of aberration. These facts become still more curious when we reflect that, but for the unfortunate destruction by fire of almost all Roemer's observations—which had been made with instruments constructed on novel principles not adopted elsewhere till much later, the foundation of modern astronomy might have been built on them and not on Bradley's observations. It was indeed unfortunate that Roemer published so very little about his scientific labours, and it is therefore particularly interesting to get a slight insight into them through his correspondence with Huygens.

Among other matters dealt with in this volume we may mention the controversy on the theory of the centre of oscillation between Huygens and Abbé de Catelan, a man whose aim in life seems to have been to object to every new mathematical publication and to exhibit his inability to grasp any new theory. In Vol. i. of Huygens' "Opera varia," the papers written by the two opponents, as well as by Jacques Bernouilli, who took Huygens' part, have already been printed side by side; but it is interesting to see from the correspondence that Catelan's attack was slyly inserted in the Amsterdam reprint of the *Journal des Sçavans*, although it had not appeared in the original Paris edition.

The volume contains as frontispiece a plate reproducing a fine medallion of Huygens from 1679, and another showing a medal apparently struck in his honour in the same year. It is announced that his unpublished works are to appear in the volumes following immediately after those devoted to his correspondence.

J. L. E. DREYER.

## *METAPHYSICS OF BIOLOGY.*

*The Living Organism: an Introduction to the Problems of Biology.* By Alfred Earl, M.A. Pp. xiii + 271. (London: Macmillan and Co., Ltd., 1898.)

THE observer of the more recent phases of biological thought will not need to be told that during the last few years a reaction has been setting in, both in England and abroad, against any so-called mechanical theories of the origin and development of living things, and against any hypothesis which seeks in the facts of chemistry and physics for an ultimate explanation of the phenomena of life; and those who have had the opportunity of a more intimate acquaintance with this new philosophical development will know that the "neo-vitalist" adopts, as the basis of his scientific beliefs, an ontology which states that it is not true that the hierarchy of the natural sciences presents us with a material universe of which the separate parts studied by the several sciences can all be ultimately expressed in terms of one of them, biology in fact being a special case of chemistry, this of physics and so on; but that on the contrary every science deals, not with a part, but with the whole of the material universe, all the facts of which come under its survey, and as a particular manner of looking at which it is to be regarded. On this view, therefore, it is as useless ever to expect a physical explanation of the chemical atom as it is futile to hope that organic metabolism may after all turn out to be merely a specially complex chemical reaction: each science has what is, for itself, an ultimate fact, in terms of which it seeks to express the whole of nature, but which has nothing in common with the ultimate fact of any other science whatever. This ultimate fact is, for the vitalistic biologist, the living organism, and when pressed for an account of how the inanimate world is included in his science, he replies by a reference to the environment, which, we are told, is to be regarded as being made by and for the organism itself.

Now it may be that the ontology which includes, with Kant, all phenomena in but a single category is obsolete,

as these philosophers suggest, and that we must rather, with Hegel, look upon the universe from several points of view, though even Hegel, if we are not mistaken, would have made the various categories develop out of one another; but whether that be so or not, and however impossible it is at present to point to any scientifically complete demonstration of the correctness of the opposite hypothesis, it is necessary to inquire very carefully into the positive basis on which this revived vitalism, of which the present volume is an exposition, rests.

Starting with sundry somewhat loosely connected remarks on the nature of knowledge in general, and the method of biology in particular, the author, after giving a brief account of the functions of assimilation and reproduction in the living organism, touches, in a chapter on the relation of that organism to its surroundings, the key-note of his whole system. Since, we are told, the human organism is a knowing subject, the organism in general is to be regarded as not only object but also as subject; and hence all mechanical, or physical, or chemical explanations of organic function are and must ever be inadequate, because they take no account of that inexplicable residuum, the "spontaneous choice" or "selection," the "subordination to a purpose" which an organism displays in every function it performs, and most obviously of all in sensation, the act which puts it in immediate communication with its environment.

Now such a view as this seems to us to be pervaded by a most vicious anthropomorphism, due to an unfortunate confusion between the organism, or its nervous system, to which those parts of the phenomenal world outside it are related during the act of knowledge, on the one hand, and on the other the metaphysical *ego* or subject of knowledge. For knowledge is most certainly not, as the author seems to imagine (for he tells us that knowledge is part of the subject-matter of biological science) a relation between the organism and its environment, both of which are phenomenal, that is to say are events occurring in space and time, but a relation between phenomena and a timeless and spaceless noumenon, with which metaphysics alone is concerned, but with which science has nothing to do at all.

The endeavour to locate in the organism, regarded as matter for scientific inquiry, a "subjective" residuum is apt to remind one of the now discredited search for that metaphysical phantom, the "thing-in-itself," and it is incumbent upon biology, advancing along rigidly deterministic lines, to resist any attempt to transfer that "freedom of the will" which psychology cannot allow for the human organism, under the name of "spontaneous selection," to the purely objective phenomena exhibited in organic function.

There are, indeed, no grounds either in theory or in fact for regarding the organism as anything else but the transitory product of certain causes which it is the aim of the biologist to discover. When Mr. Earl speaks of constant form under an ever-changing material, he momentarily forgets the dominant fact of the evolution of form; and to whatever causes we assign this evolution, its existence is beyond a doubt; and when he speaks of the impossibility of applying quantitative conceptions to organic phenomena, he either ignores or is ignorant of certain recent work in this direction, in which, indeed, alone lies a hope for the progress of biology as a science.

Serious though the misconceptions seem to us to be which mar this essay, apart from certain minor details of arrangement to which exception might possibly be taken, and the mistake of discussing epistemological problems in a book apparently intended for beginners, we may at least hope that it will serve to convince those who may still be in doubt of the futility of attempting to apply to the living organism, which, like the subject-matter of any other science, should be studied from a strictly ætiological point of view, teleological conceptions which have not even a place in human psychology. Not that it is therefore to be supposed that when the sciences have said all they have to say our knowledge of the universe is at an end: the last word must always remain with metaphysics, in which those ideas of "freedom" and the "final cause" which science cannot accept may find their true proportions; for metaphysics looks upon the universe not merely as a continuous time-process, but as a whole, time and space being only the forms under which phenomena appear to a transcendental subject, in which the ultimate interpretation of them is to be sought, but which it is as fatal for metaphysics as it is for science to confound with the living organism.

## OUR BOOK SHELF.

*An Account of the Deep-Sea Ophiuroidea collected by the Royal Indian Marine Survey Ship "Investigator."* By R. Koehler. (Calcutta: 1899.)

This monograph, published by order of the Trustees of the Indian Museum, is well worthy its predecessors, now famous, and adds one more to the brilliant results of the *Investigator*, memorably associated with the names of Dr. A. Alcock, its editor, now superintendent of the Indian Museum, and his indefatigable co-workers in the Zoology of the Indian Seas. It is chiefly devoted to the description of forty species of Ophiurids which are new, the majority of the larger number obtained during the cruises of the ship having been already reported upon by Prof. Koehler in the *Annales des Sciences Naturelles*, as explained in the text. The new forms are of the genera *Ophiacantha* (7 species), *Amphiura* (5 sp.), *Ophioglypha* (4 sp.), *Ophiomusium*, *Ophiactis*, *Ophiochiton*, *Ophiomitra*, and *Gorgonocephalus*, each 2 sp., and thirteen other genera each 1. Interest chiefly centres in a new genus, *Ophiotypa*, obtained in the Gulf of Bengal at 1997 fathoms. *O. simplex* is the name by which the author would have it known, its special structural peculiarity being the great size of the primary plates of the disc, the aboral region of which is beset by an enormous pentagonal centro-dorsal and five equally large radials, separated by small but regular inter-radials. Interbrachial plates are present on the ventral face. Radial shields are absent, and the author, regarding this character and the small number of plates present in the disc of the adult as primitive, proceeds to a comparison with the young stages of *Amphiura*, as described by Ludwig and Fewkes, which would seem to justify the conclusion that *Ophiotypa*, as regards its skeleton, may be a persistently embryonic form.

The monograph is elaborately illustrated by fourteen exquisite plates, photo-etched from the author's drawings at the Survey of India Offices in Calcutta, and on perusal of its contents the mind reverts to the interesting series of Astrophiurids, whose "primary larval plates" and

growth stages were in 1884 described and discussed by Sladen, and conjures up theories of stalked-ancestry, pentameral symmetry, and the like. Whatever the significance of the facts, this beautiful report comes to us at an opportune moment, *à propos* of the issue of the magnificent series of "Illustrations," delineating the many novel forms discovered and described by Dr. Alcock and his co-workers in the Indian seas during the last nine to ten years. He has shown by his own share of the work that it is possible for one man, new to the task of marine investigation, to successfully handle taxonomically groups so dissimilarly ordained as the Bony Fishes and Echinoderms, to say nothing of his sterling work upon the "Carcinological Fauna" of the area. An achievement this of which he may well be proud. The *Annals and Magazine of Natural History* and *Journal of the Asiatic Society of Bengal* for the period named teem with his original communications, and to him, to Commanders Carpenter, Hoskyn, and Oldham, to Dr. A. S. Anderson, who has more recently taken up the work, their collaborators, assistants, and native artists, we tender our hearty congratulations upon the skill and persistent patient enthusiasm with which they have so long and so successfully continued their task. Work thus performed is always durable, and that of H.M. Survey ship *Investigator* will be ever conspicuous among post-Challengerian explorations of the deep sea.

We close the report with a feeling of gratitude to all concerned in its production.

## LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### Dark Lightning.

I HAVE been greatly interested by some photographs showing the rare phenomenon of dark lightning, which have recently been sent to me. So far as I know the only explanation that has ever been offered to account for them is photographic reversal, due to extreme brilliancy. This appears to me to be wholly out of the question for two reasons. In the first place, a dark line on the picture, resulting from over-exposure of a very brilliant line, would be surrounded by bright edges due to the lesser photographic action in the halation region. This is never present so far as I know, the dark flashes being minute black lines ramifying from, or in the neighbourhood of, the main discharge. Secondly, from what evidence I can gather, the dark parts of the flash are not those which appear most brilliant to the observer. Mr. Jennings, of Philadelphia, who in 1890 secured a remarkable picture (reproduced in *Photog. Times Annual*, 1891) showing a very brilliant flash with countless dark flashes covering the sky around it, tells me that the appearance to the eye was a brilliant white discharge, with fainter rose-coloured ramifications, the latter developing in the negative, or rather positive, as dark flashes.

Some years ago it occurred to me that a dark flash might be produced by a preponderance of infra-red radiations, which, as Abney has shown, undo the work of ordinary light on the plate. If we had a form of discharge capable of giving off very little actinic light, and an abundance of infra-red light, it might come out dark on a feebly illuminated background. This is of course a very wild guess, with nothing to substantiate it; but the dark flash appears to be a reality, and a poor hypothesis is perhaps better than none at all. I have recently thought that the phenomenon might perhaps be explained in another way.

We have a flash which appears darker than the sky behind it. It is inconceivable that the discharge could render the air in its path opaque, in the ordinary sense, to white light. But the light which illuminates the sky, in the case of these pictures, is not daylight, but light coming from another flash, that is made up of wave-lengths corresponding to the periods of vibration of the dissociated matter in the path of the discharge. Now, may it not be possible that in the dark flash we have a discharge, weak or nearly wanting in actinic light, which, however, renders the air in its path capable of absorbing to some extent the radiations of the wave-lengths which come from the bright flash?

Such a flash might possibly appear dark on a background feebly illuminated by light, exclusively of these wave-lengths. In other words, may we not have in the path of the dark flash dissociated molecules, radiating but feebly, and capable of taking up vibrations of periods similar to their own, coming originally from a simultaneous brighter discharge?

It might not be impossible to reproduce the phenomenon by photographing a spark in front of a light background. Sparks are almost always taken against a black background, which would account for the absence of dark flashes in pictures of artificial discharges. A heavy main spark with lateral branches would seem the most suitable kind to employ.

The best method of attacking the problem experimentally, it seems to me, would be a search for selective absorption in a partially exhausted tube.

If the source of light were continuous, any absorption would be unnoticeable, unless persisting for some time after the discharge (which is unlikely), for the time between successive discharges is great in comparison to the actual duration of one of them. Even in the case of so-called continuous discharges produced by high potential batteries, the discharge is often, and may always be, intermittent in character. The source of light should then be of no longer duration than the discharge occurring in the gas the absorption of which is to be examined.

I can think of no way of producing a white or continuous spectrum source of as short duration as, and contemporaneous with, the discharge in the tube, but by employing two tubes differently excited, the one as a light source, the other as an absorption tube, some results might be obtained.

Prof. Trowbridge found that an argon tube emitted a blue light or red light according to whether it was illuminated by means of an oscillatory or non-oscillatory discharge.

By using the blue tube as the source of light and the red tube as the absorption tube, the two being arranged so as to be illuminated simultaneously, it might be found that the red tube had the power of absorbing, to some extent, the blue radiations from the other.

I hardly think results would be obtained, but the experiment seems worth trying.

A picture taken by Mr. H. B. Lefroy, of Toronto, sent to me by Mr. Lumsden, Secretary of the Astronomical and Physical Society of Toronto, has some very curious appearances. There is an exceedingly brilliant flash running down the centre of the plate, illuminating the sky quite brilliantly in its neighbourhood. In its immediate vicinity, though not joined to it in any way, are innumerable dark, thread-like markings, which in places seem to cross each other, forming meshes. Mr. Lumsden assures me that the testimony of all photographic experts who have seen the plate is to the effect that markings of that description could only be produced in the exposure—that is, they are not due to faults in the film or the results of imperfect development. The fact that they are found only in the immediate vicinity of the bright flash is additional testimony in the same direction. These markings are wholly different from any that I have seen, not having the form of branched flashes. Something in their resemblance to photographs of sound-waves started by a spark, which I have recently made (see *Phil. Mag.* for August), suggested to me that they might possibly be due to the illumination of the sound-wave due to a powerful discharge by a second discharge. Under ordinary conditions, that is, with a uniformly illuminated background, such waves would of course be invisible, but conditions might possibly arise due to the proximity of black clouds under which they might show—a sort of "Schlieren Methode" on a large scale. I have not attempted yet to plan an arrangement of clouds, which, by acting as screens to light coming from certain directions, might render visible a region of the air in which the optical density underwent a rapid change.

Mr. Lumsden's picture shows very black clouds irregularly distributed and in close proximity to the flash.

The idea of a photograph of a thunder wave is a pleasing fancy, at all events.

It seems to me that it will be impossible to formulate even a reasonable guess as to the cause of these dark flashes until a good many pictures are brought together for comparison, and as much testimony as possible secured as to the appearance of the flashes to the eye. Personally I have seen very few of the pictures, and never the original negative.

My intention in writing this letter is not so much to advance theories accounting for the phenomenon of the dark-flash as to reawaken an interest in the subject, and bring out ideas from persons qualified to treat the matter.

Madison, Wisconsin, U.S.A. R. W. WOOD.

## Tides in the Bay of Fundy.

IN the last report of Mr. W. Bell Dawson on the Survey of Tides and Currents in Canadian Waters, the results are given of an investigation of the tides in the Bay of Fundy. The information in Mr. Dawson's report is interesting, as these tides are frequently credited as having the greatest range of any in the world, and in some books of physical geography are stated as having a range of 120 feet,[1] or more than double that which actually prevails.

As a matter of fact the range of the tides in the Bay of Fundy does not exceed that which occurs in the Bristol Channel, where the extreme recorded difference between high and low water at Chepstow is 53 feet, being the same as the "Saxby," or record tide in the Cumberland Basin, Nova Scotia. The rise above the mean level of the sea in both cases is about the same, or from 22 to 23 feet.

In the Bay of Fundy the range varies considerably at different localities. Outside the bay at Portland on the north side the range is 9½ feet, and at Cape Sable on the south side 8½ feet. In the Atlantic, on the south side of Nova Scotia, the range is from 6 to 7 feet. At the mouth of the bay at Yarmouth the range is 16 feet, and at Seal Island 18 feet. Further up, at Digby, on the south side, and St. John on the north, it increases to 27 feet. Where the bay divides above Black Rock the range is 36 feet. In the Minas Basin it varies from 41 feet at Parsboro to 48 feet at Horton Bluff and 50½ feet at Noel Bay. In the Chignecto Channel in Cumberland Bay the range is 45½ feet.

From observations obtained by tide gauges fixed at different stations, and information collected in the localities, Mr. Dawson gives the range of spring tides as follows.

The highest recorded tide is known as the "Saxby tide," which occurred in 1869. The low water mark for that tide is not given, but taking the lowest low water level recorded, the range of that tide in Cumberland Bay was 52·80 feet; the ordinary spring tide range there being 45·80 feet. The Admiralty tide tables give this as 45¼ feet.

At Moncton, the Saxby tide rose above the lowest recorded level, 38·34 feet; the next highest recorded tide being in 1887, 31·91 feet. An ordinary spring tide rises 30·25 feet above mean low water of spring tides. The Admiralty tide tables give the range at Moncton Railway as 47 feet. Mr. Dawson points out that this is misleading, this range being that above low water at the mouth of the river, from which the low water line has a considerable inclination towards the head of the estuary.

At Parsboro, in the Minas Basin, the ordinary spring tide range is 41 feet, and the extreme 47 feet; the Admiralty tide tables giving the ordinary range as 43 feet.

Mr. Murphy, the Provincial Engineer of Nova Scotia, in a paper contributed in 1867 to the Institute of Natural Science, on the tides in the Bay of Fundy, gave the range of spring tides at the head of the bay as 22 feet above mean sea level, and as varying from 50 to 60 feet above extreme low water.

Having a few years since to report on some proposed embankment works in the Bay of Minas, I made inquiries in the locality from those best able to furnish me with information as to the rise of the tides there, and came to the conclusion that at Horton the greatest range to be dealt with was 48·50 feet.

The difference in the range of the tides in Cumberland Bay, at the head of the Bay of Fundy, and in Verte Bay, Northumberland Straits, in the Gulf of St. Lawrence, is worth recording. The length of the isthmus which separates the two bays along the line of the proposed Chignecto Ship Railway is eighteen miles. The range of ordinary spring tides on the one side of this neck of land is 45·80 feet, and of the highest known tide 52·80 feet; and on the other side 13·40 feet and 5·60 feet respectively, the mean level of the sea being only 0·26 feet higher in the Cumberland Bay than in Bay Verte.

It is interesting to compare the tides in the Bay of Fundy with those in the Bristol Channel. At Bude Haven and Pembroke, at the mouth of the Channel, the rise of an ordinary spring tide is 23 feet; at the mouth of the Avon it is 40 feet; at Chepstow the range is 50 feet, and in extreme tides 53 feet, the rise above the mean level of the sea being 23½ feet. From levels taken across the land from Portishead in the Bristol Channel to Axmouth in the English Channel, with a mean tide rising 35½ feet at Portishead and 10 feet at Axmouth, the mean level of the sea was found to be 9 inches higher at the former than at the latter place.[1]

There is a tidal bore in the Bay of Fundy, but it is not so strongly developed as at some other places. It shows itself at Moncton, 19 miles from the mouth of the Petticodiac River, where the estuary consists, at low tide, of mud banks and flats, with a low water channel about 500 feet wide, and having at high water a width of half a mile. The run of the rising tide first breaks into a bore at Stoney Creek, 8 miles below Moncton, and continues to the head of the estuary at Salisbury, 13 miles above, the total distance traversed being 21 miles. Mr. Dawson describes the noise made by the approaching bore as that of a distant train, which increased to the hissing and rushing sound of broken water. The bore arrived at the point of observation eleven minutes after the sound was first heard, having the appearance of a front of broken and foaming water 2 to 3 feet in height. The mean velocity was 8·47 miles an hour, the maximum being 9·61 miles. The greatest rise of water after the bore passed was 3 feet in ten minutes. The greatest recorded height of the bore is 5 feet 4 inches.

The only other place in the bay in which a bore has been observed is in the upper part of Cobequid Bay.

W. H. WHEELER.

## *ETHNOGRAPHICAL COLLECTIONS IN GERMANY.*

THE question of the representation of primitive culture in our national museums is rapidly becoming an urgent one, not only on account of the growing importance of anthropology, but also because primitive culture itself is disappearing before civilisation. The wild man is dying out or being transformed, and the hours during which we may question him about himself are already limited. Those nations therefore which take the utmost advantage of the opportunities which remain will have something in the nature of a monopoly when primitive culture is actually extinct; and it is to them that the students of the twentieth century will have to apply for their facts.

If her present rate of progress is maintained, Germany will soon have so far distanced all other European countries as to place herself in a position of permanent and unassailable superiority. It cannot therefore but be a matter of importance to cast a glance at the present state of ethnographical museums in Germany, in order that we may form some notion of the relative position of our own.

Almost all the large cities in the German Empire possess ethnographical collections, and in such places as Leipzig, Dresden and Hamburg, these are of first-rate

[1] In Sir J. F. Herschell's "Physical Geography of the Earth," fifth edition, 1875, it is stated that: "In the Bay of Fundy the tide not commonly rises 50 feet, and, as is said, on some occasions to more than double this height." Robinson, in his "Mechanical Philosophy," in the article on Tides, says, "In the Bay of Fundy, in the harbour of Annapolis Royal the tide rises 120 feet."

[1] "Tidal Rivers." (Longman's Engineering Series, 1893.)

importance. But none of them are in the same class with Berlin, and as it is with Berlin that London ought to measure itself, these short remarks must practically be confined to the German capital.

The Königliches Museum für Völkerkunde is a large building completely devoted to ethnographical and prehistorical collections: it has three floors, the lowest devoted to prehistory; the first to the collections from Africa, Oceania and America; the second to those from Asia. For administrative purposes it is divided into five departments: the Prehistoric, the African and Oceanic, the American, the Indian, and the Chino-Japanese. Each of these departments has a keeper, who usually has two assistants under him, so that the scientific staff amounts to about twelve men. The museum has an annual grant of 50,000 marks, which is supplemented upon special occasions by the voluntary gifts of a committee of wealthy and patriotic citizens known as the "Hilfskomitée." The value of this unofficial assistance can hardly be over-estimated. It makes possible the acquisition of exceptionally fine collections when the Government grant is not alone sufficient, as in the case of Benin, and it provides the means of retaining scientific explorers and collectors in outlying parts of the world. The museum can thus command the services of well-instructed investigators, and is in a position to carry out the work of collecting in a systematic and continuous manner. Berlin is probably far less dependent on the dealer and the unscientific collector than we are in London. Altogether the Hilfskomitée appears to be a most admirable institution reflecting the greatest possible credit upon all concerned.

The housing of the collections at the Museum für Völkerkunde is also excellent. In addition to extensive basements and a domed hall with a gallery running round it, there are two large and four smaller rooms on each of the three floors. Most of these are lighted from both sides, the objects being exhibited in large free-standing metal cases with glass shelves, so that none of the specimens lie in deep shadow. The wall space between the windows and at the ends of the rooms is thus available for maps and diagrams, of which there are great numbers; there is also room for numerous "mannikins," or life-sized models of representatives of various tribes, all carefully coloured, and dressed and armed in the style of their respective countries. These figures, with excellent models of houses, canoes and other large objects, and with ample and carefully written labels, afford a far more vivid picture of primitive life than can be obtained from books alone. The arrangement of the collections is geographical, but occasionally comparative series, known as "Vergleichende Gruppen," are exhibited; this is especially the case in the Indian Section. A library and a lecture theatre are important adjuncts to the building, and the latter brings the museum into direct connection with anthropological teaching. This has obvious advantages, for it probably enables the staff to stimulate the interest in ethnology of many students who afterwards become connected with Colonial administration.

Enough has perhaps been said to illustrate the advantages which Germany enjoys in the acquisition of ethnographical collections and in the dissemination of ethnological knowledge. Compared with our own, her position is very striking. We have no independent ethnographical museum, for at present we can only use for the purpose a section of the Department of British and mediæval antiquities at the British Museum. The officials of this Department, with so many other claims upon their attention, cannot be expected to compete with the organised staff at Berlin, who concentrate their whole attention on ethnographical studies. Against continuous and systematic collection we can only set occasional and limited acquisitions. Under such conditions, the race between Great Britain and Germany is a race between Argus and a blind man. Nor can we flatter ourselves that we are to be eclipsed by Berlin alone; for Leipzig is already a serious rival, and Dresden is considering the erection of a new museum of ethnography. In numerous other towns there are abundant signs of activity.

If it is asked how it is that the Germans have outstripped us in this manner, several reasons at once suggest themselves. To begin with, the rapid commercial and Colonial expansion of Germany during the last thirty years has been the expansion of the best educated people in Europe. Thus there has been little tendency to regard savage races from the point of view of a popular show, and a widespread capacity to assign to primitive culture its due scientific importance. If this is the attitude of the people as a whole, it is but natural that in officials, travellers and merchants a taste for ethnology is easily awakened. And as these are the classes in which a museum would naturally find its most useful allies, the national collections have greatly benefited by their interest and co-operation. The introduction to the Guide to the Museum für Völkerkunde contains a large proportion of official names in its long list of donors. Naval and military officers, consuls, doctors and administrators, are all conspicuous in their turn. The museum has also enjoyed the support of more exalted personages, for the German Emperors have all given proof of their sympathy upon various occasions. Again, the German museums appear in many respects to be worked more economically than our own. Their hours of closing are early, so that artificial lighting is not required in the galleries; they are also closed during at least one day in each week, which enables scientific studies to be carried on with the minimum of interruption, and the work of cleaning to be executed by a smaller staff. The fittings are also arranged with less regard for high finish than for practical and serviceable qualities. Finally, the wonderful energy and initiative of the veteran Prof. Bastian must not be forgotten. He has pressed the claims of ethnography with untiring enthusiasm for many years, and has had the reward of living to see the museum which he directs take the first place among the ethnographical museums of the world.

Comparisons are proverbially odious, and that which one is compelled to draw between Berlin and London is not gratifying to national pride. It is hard to believe that we can continue satisfied with present conditions, and sooner or later a change must come. Let all scientific men, whether their immediate interests lie in the direction of ethnography or not, lend their sympathy and support to any movement which promises to introduce a new order of things. But the old order must be changed quickly, or it may be too late. Even now it is doubtful whether we can ever make up all the ground which has been lost, for in some parts of the world specimens of primitive art are vanishing with such rapidity that complete collections are perhaps unattainable. But a serious effort made at the present time would be crowned at least with a comparative success; and the first thing to be done is to house in a more satisfactory manner what we already possess. It would surely be desirable to unite under one roof the collections which illustrate primitive culture, and those which illustrate the physical characteristics of the different branches of mankind. Meanwhile it should be freely admitted that we have much to learn from continental nations, for not only Germany but also Holland can give us useful lessons in the ethnographical exploitation of a Colonial Empire. But Berlin is the model which we should set before our eyes: the frank admission of this fact will be the best preliminary to a more satisfactory state of affairs.

## THE DOVER MEETING OF THE BRITISH ASSOCIATION.

IT is hardly yet possible to give anything like an accurate estimate of the number of members likely to be present at the meeting of the Association, but it is probable that there will be at least 1500 visitors. The foreign members of the Association will be well represented. Prof. Chappuis, of Paris, will discuss Thermometry in Section A. It is likely that Prof. Remsen will pay a flying visit to the meeting. Amongst other Americans who have promised to attend are Prof. Rotch, of the Blue Hill Observatory, Prof. Bauer, of the Magnetic and Geodetic Survey, Profs. Barker, Carl Barus, Campbell, Thurston and Scott. Prof. Calmette, of the Pasteur Institute, may possibly attend, but he is at present engaged on the Plague Commission at Oporto: Prof. Kossel, of Marburg, is with him, but hopes to come to Dover if possible. Prof. Kronecker, of Berne, will be also present, so that the foreign physiologists are well represented. Of foreign chemists, besides those mentioned, are Profs. Ladenburg and Fittig and Georges Lemoine. Geography will be represented by Prof. Hjort, of Christiania; Dr. Gerhard Schott, of the Deutsche Seewarte, who will speak on the results of the *Valdivia* Deep Sea Exploration; H. Arctowski, who will read a paper on Arctic Exploration; Admiral Markaroff, of the Russian Navy, will also attend. Abbé Renard, of Ghent, Dr. van Rijckevosel, Prof. Julin, of Liége, Prof. Cyon are a few of the other celebrated foreign men of science who are expected.

The question of accommodation of the visitors has reached a very acute stage, if we may judge from the letters which have appeared in various London papers. Dover lodging-house keepers and their agents persist in thinking that the meeting of the Association will permit Ascot week charges to be made. There are lodgings of all kinds to be found at really moderate charges without difficulty, and the local secretaries are willing to do all in their power to assist members to obtain such accommodation. The strongest representations have been made to the agents on the subject, and it is probable that there will be no further difficulties; but of course it is hard to remove an impression which has got abroad.

The installation of the Marconi system of wireless telegraphy has now been made in the Town Hall, and a sufficiently lofty pole has been erected to permit of the direct transmission of messages to Wimereux. It is intended that Prof. Fleming should transmit a message of congratulation on the evening of his lecture to the meeting held at Rome on the same day, and that the reply will reach Boulogne by the ordinary wire, and be transmitted by the wireless system before the meeting terminates. Demonstrations of the Marconi system of telegraphy will take place at the Mayor's conversazione on Thursday evening.

It is hoped that about 400 of the French men of science will attend the luncheon to members of the French Association on Saturday. Some twenty Belgian geologists, who have been visiting London during the past ten days, will also be present.

On the occasion of the French visit there will be special facilities for the inspection of the Castle, which will be closed to the general public on the afternoon of Saturday, to permit the military authorities to devote themselves entirely to the members of the British Association and their guests.

The details of the foreign tour are all settled. Those who take part in this tour will have every occasion to look back with pleasure upon a very pleasant visit. At most of the towns visited there will be official receptions, with something of a special nature at Brussels on Sunday, September 24.

The following details of the work in the Sections, omitted from last week's article, have now been supplied.

In Section C (Geology) the address of the President, Sir Archibald Geikie, will, it is hoped, be delivered on Saturday, September 16, in order that the members of the French Association may be present. The address will deal with matters of equal interest to geologists and physicists. Reports will be presented by a committee appointed at the Toronto meeting to investigate the Pleistocene flora and fauna of Canada; by a committee which has been securing photographic records of the disappearing drift section at Moel Tryfan; by the three committees appointed a short time ago to investigate the ossiferous caves at Uphill, near Weston-super-Mare, the Ty-Newydd caves, and the Irish elk remains in the Isle of Man. The report of the committee which has been engaged for some years in collecting photographs of geological interest in the British Isles, will this year be accompanied by that of a similar committee appointed for the same purpose in Canada; and reports may be expected from other committees on erratic blocks, on life-zones in British carboniferous rocks, and on the registration of type specimens.

The chief interest of this Section will, no doubt, centre round the explorations for coal in Kent, and communications on this subject from Prof. Boyd Dawkins and Mr. Robert Etheridge will be awaited with expectation: in connection with this subject Mr. Jukes-Browne promises a paper on a boring made through the chalk at Dieppe in 1898. Many French and Belgian geologists will, it is hoped, take part in the discussion on this and kindred subjects, especially as the Belgian Geological Society is holding a special meeting at Dover during that of the British Association. Among foreign visitors Prof. van den Broeck promises a paper on the Iguanodons of Bernissart, and Prof. Renard one on the origin of chondritic meteorites.

Among papers of local interest will be one by Prof. Boyd Dawkins on the geology of the Channel Tunnel; one by Dr. Rowe on the Dover chalk; and one by Captain McDakin on coast erosion. Among other papers promised in this Section may be mentioned Prof. Sollas on homotaxy and on contemporaneity, and also on the origin of flint; Mr. Vaughan Cornish on photographs of wave phenomena; Dr. F. Moreno on Neomylodon; Prof. Watts on the Mount Sorel granite; Mr. G. Abbott on water zones and their influence on concretions; Mr. Plunkett on the Fermanagh Caves; and Dr. Tempest Anderson on the 1898 eruption of Vesuvius.

In Section G (Mechanical Science) the programme of papers to be read and discussed is as follows:—Thursday, Presidential Address by Sir William White, K.C.B., F.R.S.; the Dover Admiralty Harbour Works, by W. Mathews; non-inflammable wood and its use in warships, by E. Marshall Fox. Friday, a short history of the engineering works of the Suez Canal to the present time, by Sir Charles Hartley, K.C.M.G; fast cross-Channel steamers, by Hon. C. A. Parsons, F.R.S.; the Niclausse water-tube boiler, by M. Robinson; the discharge of torpedoes below water, by Captain Lloyd. Saturday, the erection of Alexander III. Bridge in Paris, by A. Alby (of Paris). Monday, electrical machinery on board ship, by A. Siemens; earth currents from electric tramways, by J. Swinburne; some recent applications of electrometallurgy to chemical engineering, by Sherard Cowper Coles; signalling without contact, a new system of railway signalling, by Wilfrid S. Boult. Tuesday, recent experiences with steam on common roads, by J. I. Thornycroft, F.R.S.; the Dymchurch wall and the reclamation of Romney Marsh, by E. Case; an instrument for gauging the circularity of boiler furnaces and producing a diagram, by T. Messenger; and the sea lights of the south and south-east coasts of England, including the Channel and Scilly Islands, by T. Kenward.

INAUGURAL ADDRESS BY PROF. SIR MICHAEL FOSTER, K.C.B., SEC.R.S., PRESIDENT OF THE ASSOCIATION.

HE who until a few minutes ago was your President said somewhere at the meeting at Bristol, and said with truth, that among the qualifications needed for the high honour of Presidency of the British Association for the Advancement of Science, that of being old was becoming more and more dominant. He who is now attempting to speak to you feels that he is rapidly earning that distinction. But the Association itself is older than its President; it has seen pass away the men who, wise in their generation, met at York on September 27, 1831, to found it: it has seen other great men who in bygone years served it as Presidents, or otherwise helped it on, sink one after another into the grave. Each year, indeed, when it plants its flag as a signal of its yearly meeting, that flag floats half-mast high in token of the great losses which the passing year has brought. This year is no exception; the losses, indeed, are perhaps unwontedly heavy. I will not attempt to call over the sad roll-call; but I must say a word about one who was above most others a faithful and zealous friend of the Association. Sir Douglas Galton joined the Association in 1860. From 1871 to 1895, as one of the General Secretaries, he bore, and bore to the great good of the Association, a large share of the burden of the Association's work. How great that share was is perhaps especially known to the many men, among whom I am proud to count myself, who during his long term of office served in succession with him as brother General Secretary. In 1895, at Ipswich, he left the post of General Secretary, but only to become President. So long and so constantly did he labour for the good of the Association that he seemed to be an integral part of it, and meeting as we do to-day, and as we henceforward must do, without Douglas Galton, we feel something greatly missing. This year, perhaps even more than in other years, we could have wished him to be among us; for to-day the Association may look with joy, not unmixed with pride, on the realisation of a project in forwarding which it has had a conspicuous share, on the commencement of an undertaking which is not only a great thing in itself, but which, we trust, is the beginning of still greater things to come. And the share which the Association has had in this was largely Sir Douglas Galton's doing. In his Address as President of Section A, at the meeting of the Association at Cardiff in 1891, Prof. Oliver Lodge expounded with pregnant words how urgently, not pure science only, but industry and the constructive arts—for the interests of these are ever at bottom the same—needed the aid of some national establishment for the prosecution of prolonged and costly physical researches, which private enterprise could carry out in a lame fashion only, if at all. Lodge's words found an echo in many men's minds; but the response was for a long while in men's minds only. In 1895 Sir Douglas Galton, having previously made a personal study of an institution analogous to the one desired—namely, the Reichsanstalt at Berlin—seized the opportunity offered to him as President of the Association at Ipswich to insist, with the authority not only of the head for the time being of a great scientific body, but also of one who himself knew the ways and wants at once of science and of practical life, that the thing which Lodge and others had hoped for was a thing which could be done, and ought to be done at once. And now to-day we can say it has been done. The National Physical Laboratory has been founded. The Address at Ipswich marked the beginning of an organised effort which has at last been crowned with success. A feeling of sadness cannot but come over us when we think that Sir Douglas Galton was not spared to see the formal completion of the scheme whose birth he did so much to help, and which, to his last days, he aided in more ways than one. It is the old story—the good which men do lives after them.

Still older than the Association is this nineteenth century, now swiftly drawing to its close. Though the century itself has yet some sixteen months to run, this is the last meeting of the British Association which will use the numbers eighteen hundred to mark its date.

The eyes of the young look ever forward; they take little heed of the short though ever-lengthening fragment of life which lies behind them; they are wholly bent on that which is to come. The eyes of the aged turn wistfully again and again to the past; as the old glide down the inevitable slope their present becomes a living over again the life which has gone before, and the future takes on the shape of a brief lengthening of the past. May I this evening venture to give rein to the impulses of advancing years? May I, at this last meeting of the Association in the eighteen hundreds, dare to dwell for a while upon the past, and to call to mind a few of the changes which have taken place in the world since those autumn days in which men were saying to each other that the last of the seventeen hundreds was drawing towards its end?

Dover in the year of our Lord seventeen hundred and ninety-nine was in many ways unlike the Dover of to-day. On moonless nights men groped their way in its narrow streets by the help of swinging lanterns and smoky torches, for no lamps lit the ways. By day the light of the sun struggled into the houses through narrow panes of blurred glass. Though the town then, as now, was one of the chief portals to and from the countries beyond the seas, the means of travel were scanty and dear, available for the most part to the rich alone, and, for all, beset with discomfort and risk. Slow and uncertain was the carriage of goods, and the news of the world outside came to the town—though it from its position learnt more than most towns—tardily, fitfully, and often falsely. The people of Dover sat then much in dimness, if not in darkness, and lived in large measure on themselves. They who study the phenomena of living beings tell us that light is the great stimulus of life and that the fulness of the life of a being or of any of its members may be measured by the variety, the swiftness, and the certainty of the means by which it is in touch with its surroundings. Judged from this standpoint then life at Dover, as indeed elsewhere, must have fallen far short of the life of to-day.

The same study of living beings, however, teaches us that while from one point of view the environment seems to mould the organism, from another point the organism seems to be master of its environment. Going behind the change of circumstances, we may raise the question, the old question, Was life in its essence worth more then than now? Has there been a real advance?

Let me at once relieve your minds by saying that I propose to leave this question in the main unanswered. It may be, or it may not be, that man's grasp of the beautiful and of the good, if not looser, is not firmer than it was a hundred years ago. It may be, or it may not be, that man is no nearer to absolute truth, to seeing things as they really are, than he was then. I will merely ask you to consider with me for a few minutes how far, and in what ways, man's laying hold of that aspect of or part of truth which we call natural knowledge, or sometimes science, differed in 1799 from what it is to-day, and whether that change must not be accounted a real advance, a real improvement in man.

I do not propose to weary you by what in my hands would be the rash effort of attempting a survey of all the scientific results of the nineteenth century. It will be enough if for a little while I dwell on some few of the salient features distinguishing the way in which we nowadays look upon, and during the coming week shall speak of, the works of nature around us—though those works themselves, save for the slight shifting involved in a secular change, remain exactly the same—from the way in which they were looked upon and might have been spoken of at a gathering of philosophers at Dover in 1799. And I ask your leave to do so.

In the philosophy of the ancients, earth, fire, air, and water were called "the elements." It was thought, and rightly thought, that a knowledge of them and of their attributes was a necessary basis of a knowledge of the ways of nature. Translated into modern language, a knowledge of these "elements" of old means a knowledge of the composition of the atmosphere, of water, and of all the other things which we call matter, as well as a knowledge of the general properties of gases, liquids, and solids, and of the nature and effects of combustion. Of all these things our knowledge to-day is large and exact, and, though ever enlarging, in some respects complete. When did that knowledge begin to become exact?

To-day the children in our schools know that the air which wraps round the globe is not a single thing, but is made up of two things, oxygen and nitrogen,[1] mingled together. They know, again, that water is not a single thing, but the product of two things, oxygen and hydrogen, joined together. They know that when the air makes the fire burn and gives the animal life, it is the oxygen in it which does the work. They know that all

[1] Some may already know that there is at least a third thing, argon.

round them things are undergoing that union with oxygen which we call oxidation, and that oxidation is the ordinary source of heat and light. Let me ask you to picture to yourselves what confusion there would be to-morrow, not only in the discussions at the sectional meetings of our Association, but in the world at large, if it should happen that in the coming night some destroying touch should wither up certain tender structures in all our brains, and wipe out from our memories all traces of the ideas which cluster in our minds around the verbal tokens, oxygen and oxidation. How could any of us, not the so-called man of science alone, but even the man of business and the man of pleasure, go about his ways lacking those ideas? Yet those ideas were in 1799 lacking to all but a few.

Although in the third quarter of the seventeenth century the light of truth about oxidation and combustion had flashed out in the writings of John Mayow, it came as a flash only, and died away as soon as it had come. For the rest of that century, and for the greater part of the next, philosophers stumbled about in darkness, misled for the most of the time by the phantom conception which they called phlogiston. It was not until the end of the third quarter of the eighteenth century that the new light, which has burned steadily ever since, lit up the minds of the men of science. The light came at nearly the same time from England and from France. Rounding off the sharp corners of controversy, and joining, as we may fitly do to-day, the two countries as twin bearers of a common crown, we may say that we owe the truth to Priestley, to Lavoisier, and Cavendish. If it was Priestley who was the first to demonstrate the existence of what we now call oxygen, it is to Lavoisier we owe the true conception of the nature of oxidation and the clear exposition of the full meaning of Priestley's discovery, while the knowledge of the composition of water, the necessary complement of the knowledge of oxygen, came to us through Cavendish and, we may perhaps add, through Watt.

The date of Priestley's discovery of oxygen is 1774, Lavoisier's classic memoir "on the nature of the principle which enters into combination with metals during calcination" appeared in 1775, and Cavendish's paper on the composition of water did not see the light until 1784.

During the last quarter of the eighteenth century this new idea of oxygen and oxidation was struggling into existence. How new was the idea is illustrated by the fact that Lavoisier himself at first spoke of that which he was afterwards, namely in 1778, led to call oxygen, the name by which it has since been known, as "the principle which enters into combination." What difficulties its acceptance met with is illustrated by the fact that Priestley himself refused to the end of his life to grasp the true bearings of the discovery which he had made. In the year 1799 the knowledge of oxygen, of the nature of water and of air, and indeed the true conception of chemical composition and chemical change, was hardly more than beginning to be, and the century had to pass wholly away before the next great chemical idea, which we know by the name of the Atomic Theory of John Dalton, was made known. We have only to read the scientific literature of the time to recognise that a truth which is now not only woven as a master-thread into all our scientific conceptions, but even enters largely into the everyday talk and thoughts of educated people, was a hundred years ago struggling into existence among the philosophers themselves. It was all but absolutely unknown to the large world outside those select few.

If there be one word of science which is writ large on the life of the present time, it is the word "electricity"; it is, I take it, writ larger than any other word. The knowledge which it denotes has carried its practical results far and wide into our daily life, while the theoretical conceptions which it signifies pierce deep into the nature of things. We are to-day proud, and justly proud, both of the material triumphs and of the intellectual gains which it has brought us, and we are full of even larger hopes of it in the future.

At what time did this bright child of the nineteenth century have its birth?

He who listened to the small group of philosophers of Dover, who in 1799 might have discoursed of natural knowledge, would perhaps have heard much of electric machines, of electric sparks, of the electric fluid, and even of positive and negative electricity; for frictional electricity had long been known and even carefully studied. Probably one or more of the group, dwelling on the observations which Galvani, an Italian, had made known some twenty years before, developed views on the connection of electricity with the phenomena of living bodies. Possibly one of them was exciting the rest by telling how he had just heard that a professor at Pavia, one Volta, had discovered that electricity could be produced not only by rubbing together particular bodies, but by the simple contact of two metals, and had thereby explained Galvani's remarkable results. For, indeed, as we shall hear from Prof. Fleming, it was in that very year, 1799, that electricity as we now know it took its birth. It was then that Volta brought to light the apparently simple truths out of which so much has sprung. The world, it is true, had to wait for yet some twenty years before both the practical and the theoretic worth of Volta's discovery became truly pregnant, under the fertilising influence of another discovery. The loadstone and magnetic virtues had, like the electrifying power of rubbed amber, long been an old story. But, save for the compass, not much had come from it. And even Volta's discovery might have long remained relatively barren had it been left to itself. When, however, in 1819, Oersted made known his remarkable observations on the relations of electricity to magnetism, he made the contact needed for the flow of a new current of ideas. And it is perhaps not too much to say that those ideas, developing during the years of the rest of the century with an ever-accelerating swiftness, have wholly changed man's material relations to the circumstances of life, and at the same time carried him far in his knowledge of the nature of things.

Of all the various branches of science, none perhaps is to-day, none for these many years past has been, so well known to, even if not understanded by, most people as that of geology. Its practical lessons have brought wealth to many; its fairy tales have brought delight to more; and round it hovers the charm of danger, for the conclusions to which it leads touch on the nature of man's beginning.

In 1799 the science of geology, as we know it, was struggling into birth. There had been from of old cosmogonies, theories as to how the world had taken shape out of primæval chaos. In that fresh spirit which marked the zealous search after natural knowledge pursued in the middle and latter part of the seventeenth century, the brilliant Stenson, in Italy, and Hooke, in our own country, had laid hold of some of the problems presented by fossil remains; and Woodward, with others, had laboured in the same field. In the eighteenth century, especially in its latter half, men's minds were busy about the physical agencies determining or modifying the features of the earth's crust; water and fire, subsidence from a primæval ocean and transformation by outbursts of the central heat, Neptune and Pluto, were being appealed to, by Werner on the one hand, and by Desmarest on the other, in explanation of the earth's phenomena. The way was being prepared, theories and views were abundant, and many sound observations had been made; and yet the science of geology, properly so called, the exact and proved knowledge of the successive phases of the world's life, may be said to date from the closing years of the eighteenth century.

In 1873 James Hutton put forward in a brief memoir his "Theory of the Earth," which in 1795, two years before his death, he expanded into a book; but his ideas failed to lay hold of men's minds until the century had passed away, when in 1802 they found an able expositor in John Playfair. The very same year that Hutton published his theory, Cuvier came to Paris and almost forthwith began, with Brongniart, his immortal researches into the fossils of Paris and its neighbourhood. And four years later, in the year 1799 itself, William Smith's tabular list of strata and fossils saw the light. It is, I believe, not too much to say that out of these geology, as we now know it, sprang. It was thus in the closing years of the eighteenth century that was begun the work which the nineteenth century has carried forward to such great results. But at that time only the select few had grasped the truth, and even they only the beginning of it. Outside a narrow circle the thoughts, even of the educated, about the history of the globe were bounded by the story of the Delnge—though the story was often told in a strange fashion—or were guided by fantastic views of the plastic forces of a sportive nature.

In another branch of science, in that which deals with the problems presented by living beings, the thoughts of men in 1799 were also very different from the thoughts of men to-day.

It is a very old quest, the quest after the knowledge of the nature of living beings, one of the earliest on which man set out; for it promised to lead him to a knowledge of himself, a promise which perhaps is still before us, but the fulfilment of which is as yet far off. As time has gone on, the pursuit of natural knowledge has seemed to lead man away from himself into the furthermost parts of the universe, and into secret workings of nature in which he appears to be of little or no account; and his knowledge of the nature of living things, and so of his own nature, has advanced slowly, waiting till the progress of other branches of natural knowledge can bring it aid. Yet in the past hundred years, the biologic sciences, as we now call them, have marched rapidly onward.

We may look upon a living body as a machine doing work in accordance with certain laws, and may seek to trace out the working of the inner wheels, how these raise up the lifeless dust into living matter, and let the living matter fall away again into dust, giving out movement and heat. Or we may look upon the individual life as a link in a long chain, joining something which went before to something about to come, a chain whose beginning lies hid in the farthest past, and may seek to know the ties which bind one life to another. As we call up to view the long series of living forms, living now or flitting like shadows on the screen of the past, we may strive to lay hold of the influences which fashion the garment of life. Whether the problems of life are looked upon from the one point of view or the other, we to-day, not biologists only, but all of us, have gained a knowledge hidden even from the philosophers a hundred years ago.

Of the problems presented by the living body viewed as a machine, some may be spoken of as mechanical, others as physical, and yet others as chemical. while some are, apparently at least, none of these. In the seventeenth century William Harvey, laying hold of the central mechanism of the blood stream, opened up a path of inquiry which his own age and the century which followed trod with marked success. The knowledge of the mechanics of the animal and of the plant advanced apace; but the physical and chemical problems had yet to wait. The eighteenth century, it is true, had its physics and its chemistry; but, in relation at least to the problems of the living being, a chemistry which knew not oxygen and a physics which knew not the electricity of chemical action were of little avail. The philosopher of 1799, when he discussed the functions of the animal or of the plant involving chemical changes, was fain for the most part, as were his predecessors in the century before, to have recourse to such vague terms as "fermentation" and the like; to-day our treatises on physiology are largely made up of precise and exact expositions of the play of physical agencies and chemical bodies in the living organism. He made use of the words "vital force" or "vital principle," not as an occasional, but as a common explanation of the phenomena of the living body. During the present century, especially during its latter half, the idea embodied in those words has been driven away from one seat after another; if we use it now when we are dealing with the chemical and physical events of life we use it with reluctance, as a *deus ex machina* to be appealed to only when everything else has failed.

Some of the problems—and those, perhaps, the chief problems—of the living body have to be solved neither by physical nor by chemical methods, but by methods of their own. Such are the problems of the nervous system. In respect to these the men of 1799 were on the threshold of a pregnant discovery. During the latter part of the present century, and especially during its last quarter, the analysis of the mysterious processes in the nervous system which issue as feeling, thought, and power to move, has been pushed forward with a success conspicuous in its practical, and full of promise in its theoretical, gains. That analysis may be briefly described as a following up of threads. We now know that what takes place along a tiny thread which we call a nerve-fibre differs from that which takes place along its fellow-threads, that differing nervous impulses travel along different nerve-fibres, and that nervous and psychical events are the outcome of the clashing of nervous impulses as they sweep along the closely-woven web of living threads of which the brain is made. We have learnt by experiment and by observation that the pattern of the web determines the play of the impulses, and we can already explain many of the obscure problems, not only of nervous disease, but of nervous life, by an analysis which is a tracking out the devious and linked paths of nervous threads. The very beginning of this analysis was known in 1799. Men knew that nerves were the agents of feeling and of the movements of muscles; they had learnt much about what this part or that part of the brain could do; but they did not know that one nerve-fibre differed from another in the very essence of its work. It was just about the end of the past century, or the beginning of the present one, that an English surgeon began to ponder over a conception which, however, he did not make known until some years later, and which did not gain complete demonstration and full acceptance until still more years had passed away. It was in 1811, in a tiny pamphlet published privately, that Charles Bell put forward his "New Idea" that the nervous system was constructed on the principle that "the nerves are not single nerves possessing various powers, but bundles of different nerves, whose filaments are united for the convenience of distribution, but which are distinct in office as they are in origin from the brain."

Our present knowledge of the nervous system is to a large extent only an exemplification and expansion of Charles Bell's "New Idea," and has its origin in that.

If we pass from the problems of the living organism viewed as a machine to those presented by the varied features of the different creatures who have lived or who still live on the earth, we at once call to mind that the middle years of the present century mark an epoch in biologic thought such as never came before, for it was then that Charles Darwin gave to the world the "Origin of Species."

That work, however, with all the far-reaching effects which it has had, could have had little or no effect, or, rather, could not have come into existence, had not the earlier half of the century been in travail preparing for its coming. For the germinal idea of Darwin appeals, as to witnesses, to the results of two lines of biologic investigation which were almost unknown to the men of the eighteenth century.

To one of these lines I have already referred. Darwin, as we know, appealed to the geological record: and we also know how that record, imperfect as it was then, and imperfect as it must always remain, has since his time yielded the most striking proofs of at least one part of his general conception. In 1799 there was, as we have seen, no geological record at all.

Of the other line I must say a few words.

To-day the merest beginner in biologic study, or even that exemplar of acquaintance without knowledge, the general reader, is aware that every living being, even man himself, begins its independent existence as a tiny ball, of which we can, even acknowledging to the full the limits of the optical analysis at our command, assert with confidence that in structure, using that word in its ordinary sense, it is in all cases absolutely simple. It is equally well known that the features of form which supply the characters of a grown-up living being, all the many and varied features of even the most complex organism, are reached as the goal of a road, at times a long road, of successive changes; that the life of every being, from the ovum to its full estate, is a series of shifting scenes, which come and go, sometimes changing abruptly, sometimes melting the one into the other, like dissolving views, all so ordained that often the final shape with which the creature seems to begin, or is said to begin, its life in the world is the outcome of many shapes, clothed with which it has in turn lived many lives before its seeming birth.

All or nearly all the exact knowledge of the laboured way in which each living creature puts on its proper shape and structure is the heritage of the present century. Although the way in which the chick is moulded in the egg was not wholly unknown even to the ancients, and in later years had been told, first in the sixteenth century by Fabricius, then in the seventeenth century in a more clear and striking manner by the great Italian naturalist Malpighi, the teaching thus offered had been neglected or misinterpreted. At the close of the eighteenth century the dominant view was that in the making of a creature out of the egg there was no putting on of wholly new parts, no epigenesis. It was taught that the entire creature lay hidden in the egg, hidden by reason of the very transparency of its substance, lay ready-made but folded up, as it were, and that the process of development within the egg or within the womb was a mere unfolding, a simple evolution. Nor did men shrink from accepting the logical outcome of such a view—namely, that within the unborn creature itself lay in like manner, hidden and folded up, its offspring also, and within that again its offspring in turn, after the fashion of a cluster of

ivory balls carved by Chinese hands, one within the other. This was no fantastic view put forward by an imaginative dreamer; it was seriously held by sober men, even by men like the illustrious Haller, in spite of their recognising that as the chick grew in the egg some changes of form took place. Though so early as the middle of the eighteenth century Friedrich Caspar Wolff and, later on, others had strenuously opposed such a view, it held its own, not only to the close of the century, but far on into the next. It was not until a quarter of the present century had been added to the past that Von Baer made known the results of researches which once and for all swept away the old view. He and others working after him made it clear that each individual puts on its final form and structure, not by an unfolding of pre-existing hidden features, but by the formation of new parts through the continued differentiation of a primitively simple material. It was also made clear that the successive changes which the embryo undergoes in its progress from the ovum to maturity are the expression of morphologic laws, that the progress is one from the general to the special, and that the shifting scenes of embryonic life are hints and tokens of lives lived by ancestors in times long past.

If we wish to measure how far off in biologic thought the end of the last century stands, not only from the end but even from the middle of this one, we may imagine Darwin striving to write the "Origin of Species" in 1799. We may fancy him being told by philosophers that one group of living beings differed from another group because all its members and all their ancestors came into existence at one stroke when the firstborn progenitor of the race, within which all the rest were folded up, stood forth as the result of a creative act. We may fancy him listening to a debate between the philosopher who maintained that all the fossils strewn in the earth were the remains of animals or plants churned up in the turmoil of a violent universal flood, and dropped in their places as the waters went away, and him who argued that such were not really the "spoils of living creatures," but the products of some playful plastic power which out of the superabundance of its energy fashioned here and there the lifeless earth into forms which imitated, but only imitated, those of living things. Could he amid such surroundings by any flight of genius have beat his way to the conception for which his name will ever be known?

Here I may well turn away from the past. It is not my purpose, nor, as I have said, am I fitted, nor is this perhaps the place, to tell even in outline the tale of the work of science in the nineteenth century. I am content to have pointed out that the two great sciences of chemistry and geology took their birth, or at least began to stand alone, at the close of the last century, and have grown to be what we know them now within about a hundred years, and that the study of living beings has within the same time been so transformed as to be to-day something wholly different from what it was in 1799. And, indeed, to say more would be to repeat almost the same story about other things. If our present knowledge of electricity is essentially the child of the nineteenth century, so also is our present knowledge of many other branches of physics. And those most ancient forms of exact knowledge, the knowledge of numbers and of the heavens, whose beginning is lost in the remote past, have, with all other kinds of natural knowledge, moved onward during the whole of the hundred years with a speed which is ever increasing. I have said, I trust, enough to justify the statement that in respect to natural knowledge a great gulf lies between 1799 and 1899. That gulf, moreover, is a twofold one: not only has natural knowledge been increased, but men have run to and fro spreading it as they go. Not only have the few driven far back round the full circle of natural knowledge the dark clouds of the unknown which wrap us all about, but also the many walk in the zone of light thus increasingly gained. If it be true that the few to-day are, in respect to natural knowledge, far removed from the few of those days, it is also true that nearly all which the few alone knew then, and much which they did not know, has now become the common knowledge of the many.

What, however, I may venture to insist upon here is that the difference in respect to natural knowledge, whatever be the case with other differences between then and now, is undoubtedly a difference which means progress. The span between the science of that time and the science of to-day is beyond all question a great stride onwards.

We may say this, but we must say it without boasting. For the very story of the past which tells of the triumphs of science bids the man of science put away from him all thoughts of vain-glory. And that by many tokens.

Whoever, working at any scientific problem, has occasion to study the inquiries into the same problem made by some fellow-worker in the years long gone by, comes away from that study humbled by one or other of two different thoughts. On the one hand, he may find, when he has translated the language of the past into the phraseology of to-day, how near was his forerunner of old to the conception which he thought, with pride, was all his own, not only so true but so new. On the other hand, if the ideas of the investigator of old, viewed in the light of modern knowledge, are found to be so wide of the mark as to seem absurd, the smile which begins to play upon the lips of the modern is checked by the thought, Will the ideas which I am now putting forth, and which I think explain so clearly, so fully, the problem in hand, seem to some worker in the far future as wrong and as fantastic as do these of my forerunner to me? In either case his personal pride is checked. Further, there is written clearly on each page of the history of science, in characters which cannot be overlooked, the lesson that no scientific truth is born anew, coming by itself and of itself. Each new truth is always the offspring of something which has gone before, becoming in turn the parent of something coming after. In this aspect the man of science is unlike, or seems to be unlike, the poet and the artist. The poet is born, not made; he rises up, no man knowing his beginnings; when he goes away, though men after him may sing his songs for centuries, he himself goes away wholly, having taken with him his mantle, for this he can give to none other. The man of science is not thus creative; he is created. His work, however great it be, is not wholly his own; it is in part the outcome of the work of men who have gone before. Again and again a conception which has made a name great has come, not so much by the man's own effort as out of the fulness of time. Again and again we may read in the words of some man of old the outlines of an idea which in later days has shone forth as a great acknowledged truth. From the mouth of the man of old the idea dropped barren, fruitless: the world was not ready for it, and heeded it not; the concomitants and abutting truths which could give it power to work were wanting. Coming back again in later days, the same idea found the world awaiting it; things were in travail preparing for it; and some one, seizing the right moment to put it forth again, leapt into fame. It is not so much the men of science who make science, as some spirit which, born of the truths already won, drives the man of science onward, and uses him to win new truths in turn.

It is because each man of science is not his own master, but one of many obedient servants of an impulse which was at work long before him, and will work long after him, that in science there is no falling back. In respect to other things there may be times of darkness and times of light, there may be risings, decadences, and revivals. In science there is only progress. The path may not be always a straight line, there may be swerving to this side and to that, ideas may seem to return again and again to the same point of the intellectual compass; but it will always be found that they have reached a higher level—they have moved, not in a circle, but in a spiral. Moreover, science is not fashioned as is a house, by putting brick to brick, that which is once put remaining as it was put to the end. The growth of science is that of a living being. As in the embryo phase follows phase, and each member of the body puts on in succession different appearances, though all the while the same member, so a scientific conception of one age seems to differ from that of a following age, though it is the same one in the process of being made; and as the dim outlines of the early embryo, as the being grows, become more distinct and sharp, like a picture on a screen brought more and more into focus, so the dim gropings and searchings of the men of science of old are by repeated approximations wrought into the clear and exact conclusions of later times.

The story of natural knowledge, of science, in the nineteenth century, as, indeed, in preceding centuries, is, I repeat, a story of continued progress. There is in it not so much as a hint of falling back, not even of standing still. What is gained by scientific inquiry is gained for ever; it may be added to, it may seem to be covered up, but it can never be taken away. Confident that the progress will go on, we cannot help peering

into the years to come and straining our eyes to foresee what science will become and what it will do as they roll on. While we do so, the thought must come to us, Will all the increasing knowledge of nature avail only to change the ways of man—will it have no effect on man himself?

The material good which mankind has gained and is gaining through the advance of science is so imposing as to be obvious to every one, and the praises of this aspect of science are to be found in the mouths of all. Beyond all doubt science has greatly lessened and has markedly narrowed hardship and suffering; beyond all doubt science has largely increased and has widely diffused ease and comfort. The appliances of science have, as it were, covered with a soft cushion the rough places of life, and that not for the rich only, but also for the poor. So abundant and so prominent are the material benefits of science that in the eyes of many these seem to be the only benefits which she brings. She is often spoken of as if she were useful and nothing more, as if her work were only to administer to the material wants of man.

Is this so?

We may begin to doubt it when we reflect that the triumphs of science which bring these material advantages are in their very nature intellectual triumphs. The increasing benefits brought by science are the results of man's increasing mastery over nature, and that mastery is increasingly a mastery of mind; it is an increasing power to use the forces of what we call inanimate nature in place of the force of his own or other creatures' bodies; it is an increasing use of mind in place of muscle.

Is it to be thought that that which has brought the mind so greatly into play has had no effect on the mind itself? Is that part of the mind which works out scientific truths a mere slavish machine producing results it knows not how, having no part in the good which in its working it brings forth?

What are the qualities, the features of that scientific mind which has wrought, and is working, such great changes in man's relation to nature? In seeking an answer to this question we have not to inquire into the attributes of genius. Though much of the progress of science seems to take on the form of a series of great steps, each made by some great man, the distinction in science between the great discoverer and the humble worker is one of degree only, not of kind. As I was urging just now, the greatness of many great names in science is often, in large part, the greatness of occasion, not of absolute power. The qualities which guide one man to a small truth silently taking its place among its fellows, as these go to make up progress, are at bottom the same as those by which another man is led to something of which the whole world rings.

The features of the fruitful scientific mind are in the main three.

In the first place, above all other things, his nature must be one which vibrates in unison with that of which he is in search; the seeker after truth must himself be truthful, truthful with the truthfulness of nature. For the truthfulness of nature is not wholly the same as that which man sometimes calls truthfulness. It is far more imperious, far more exacting. Man, unscientific man, is often content with "the nearly" and "the almost." Nature never is. It is not her way to call the same two things which differ, though the difference may be measured by less than the thousandth of a milligramme or of a millimetre, or by any other like standard of minuteness. And the man who, carrying the ways of the world into the domain of science, thinks that he may treat nature's differences in any other way than she treats them herself, will find that she resents his conduct; if he in carelessness or in disdain overlooks the minute difference which she holds out to him as a signal to guide him in his search, the projecting tip, as it were, of some buried treasure, he is bound to go astray, and the more strenuously he struggles on, the farther will he find himself from his true goal.

In the second place, he must be alert of mind. Nature is ever making signs to us, she is ever whispering to us the beginnings of her secrets; the scientific man must be ever on the watch, ready at once to lay hold of nature's hint however small, to listen to her whisper however low.

In the third place, scientific inquiry, though it be pre-eminently an intellectual effort, has need of the moral quality of courage—not so much the courage which helps a man to face a sudden difficulty as the courage of steadfast endurance. Almost every inquiry, certainly every prolonged inquiry, sooner or later goes wrong. The path, at first so straight and clear, grows crooked and gets blocked; the hope and enthusiasm, or even the jaunty ease, with which the inquirer set out leave him, and he falls into a slough of despond. That is the critical moment calling for courage. Struggling through the slough he will find on the other side the wicket-gate opening up the real path; losing heart he will turn back and add one more stone to the great cairn of the unaccomplished.

But, I hear some one say, these qualities are not the peculiar attributes of the man of science; they may be recognised as belonging to almost every one who has commanded or deserved success, whatever may have been his walk of life. That is so. That is exactly what I would desire to insist, that the men of science have no peculiar virtues, no special powers. They are ordinary men, their characters are common, even commonplace. Science, as Huxley said, is organised common sense, and men of science are common men, drilled in the ways of common sense.

For their life has this feature. Though in themselves they are no stronger, no better than other men, they possess a strength which, as I just now urged, is not their own, but is that of the science whose servants they are. Even in his apprenticeship, the scientific inquirer, while learning what has been done before his time, if he learns it aright, so learns it that what is known may serve him, not only as a vantage ground whence to push off into the unknown, but also as a compass to guide him in his course. And when fitted for his work he enters on inquiry itself, what a zealous anxious guide, what a strict and, because strict, helpful schoolmistress does nature make herself to him! Under her care every inquiry, whether it bring the inquirer to a happy issue or seem to end in nought, trains him for the next effort. She so orders her ways that each act of obedience to her makes the next act easier for him, and step by step she leads him on towards that perfect obedience which is complete mastery.

Indeed, when we reflect on the potency of the discipline of scientific inquiry we cease to wonder at the progress of scientific knowledge. The results actually gained seem to fall so far short of what under such guidance might have been expected to have been gathered in that we are fain to conclude that science has called to follow her, for the most part, the poor in intellect and the wayward in spirit. Had she called to her service the many acute minds who have wasted their strength struggling in vain to solve hopeless problems, or who have turned their energies to things other than the increase of knowledge; had she called to her service the many just men who have walked straight without the need of a rod to guide them, how much greater than it has been would have been the progress of science, and how many false teachings would the world have been spared! To men of science themselves, when they consider their favoured lot, the achievements of the past should serve, not as a boast, but as a reproach.

If there be any truth in what I have been urging, that the pursuit of scientific inquiry is itself a training of special potency, giving strength to the feeble and keeping in the path those who are inclined to stray, it is obvious that the material gains of science, great as they may be, do not make up all the good which science brings or may bring to man. We especially, perhaps, in these later days, through the rapid development of the physical sciences, are too apt to dwell on the material gains alone. As a child in its infancy looks upon its mother only as a giver of good things, and does not learn till in after days how she was also showing her love by carefully training it in the way it should go, so we, too, have thought too much of the gifts of science, overlooking her power to guide.

Man does not live by bread alone, and science brings him more than bread. It is a great thing to make two blades of grass grow where before one alone grew; but it is no less great a thing to help a man to come to a just conclusion on the questions with which he has to deal. We may claim for science that while she is doing the one she may be so used as to do the other also. The dictum just quoted, that science is organised common sense, may be read as meaning that the common problems of life which common people have to solve are to be solved by the same methods by which the man of science solves his special problems. It follows that the training which does so much for him may be looked to as promising to do much for them. Such aid can come from science on two conditions

only. In the first place, this her influence must be acknowledged; she must be duly recognised as a teacher no less than as a hewer of wood and a drawer of water. And the pursuit of science must be followed, not by the professional few only, but, at least in such measure as will ensure the influence of example, by the many. But this latter point I need not urge before this great Association, whose chief object during more than half a century has been to bring within the fold of science all who would answer to the call. In the second place, it must be understood that the training to be looked for from science is the outcome, not of the accumulation of scientific knowledge, but of the practice of scientific inquiry. Man may have at his fingers' ends all the accomplished results and all the current opinions of any one or of all the branches of science, and yet remain wholly unscientific in mind; but no one can have carried out even the humblest research without the spirit of science in some measure resting upon him. And that spirit may in part be caught even without entering upon an actual investigation in search of a new truth. The learner may be led to old truths, even the oldest, in more ways than one. He may be brought abruptly to a truth in its finished form, coming straight to it like a thief climbing over the wall; and the hurry and press of modern life tempt many to adopt this quicker way. Or he may be more slowly guided along the path by which the truth was reached by him who first laid hold of it. It is by this latter way of learning the truth, and by this alone, that the learner may hope to catch something at least of the spirit of the scientific inquirer.

This is not the place, nor have I the wish, to plunge into the turmoil of controversy; but, if there be any truth in what I have been urging, then they are wrong who think that in the schooling of the young science can be used with profit only to train those for whom science will be the means of earning their bread. It may be that from the point of view of the pedagogic art the experience of generations has fashioned out of the older studies of literature an instrument of discipline of unusual power, and that the teaching of science is as yet but a rough tool in unpractised hands. That, however, is not an adequate reason why scope should not be given for science to show the value which we claim for it as an intellectual training fitted for all sorts and conditions of men. Nor need the studies of humanity and literature fear her presence in the schools, for if her friends maintain that that teaching is one-sided, and therefore misleading, which deals with the doings of man only, and is silent about the works of nature, in the sight of which he and his doings shrink almost to nothing, she herself would be the first to admit that that teaching is equally wrong which deals only with the works of nature and says nothing about the doings of man, who is, to us at least, nature's centre.

There is yet another general aspect of science on which I would crave leave to say a word. In that broad field of human life which we call politics, in the struggle, not of man with man, but of race with race, science works for good. If we look only on the surface it may at first sight seem otherwise. In no branch of science has there during these later years been greater activity and more rapid progress than in that which furnishes the means by which man brings death, suffering, and disaster on his fellow-men. If the healer can look with pride on the increased power which science has given him to alleviate human suffering and ward off the miseries of disease, the destroyer can look with still greater pride on the power which science has given him to sweep away lives and to work desolation and ruin; while the one has slowly been learning to save units, the other has quickly learnt to slay thousands. But, happily, the very greatness of the modern power of destruction is already becoming a bar to its use, and bids fair—may we hope before long?—wholly to put an end to it; in the words of Tacitus, though in another sense, the very preparations for war, through the character which science gives them, make for peace.

Moreover, not in one branch of science only, but in all, there is a deep undercurrent of influence sapping the very foundations of all war. As I have already urged, no feature of scientific inquiry is more marked than the dependence of each step forward on other steps which have been made before. The man of science cannot sit by himself in his own cave weaving out results by his own efforts, unaided by others, heedless of what others have done and are doing. He is but a bit of a great system, a joint in a great machine, and he can only work aright when he is in due touch with his fellow-workers. If his labour is to be what it ought to be, and is to have the weight which it ought to have, he must know what is being done, not by himself, but by others, and by others not of his own land and speaking his tongue only, but also of other lands and of other speech. Hence it comes about that to the man of science the barriers of manners and of speech which pen men into nations become more and more unreal and indistinct. He recognises his fellow-worker, wherever he may live and whatever tongue he may speak, as one who is pushing forward shoulder to shoulder with him towards a common goal, as one whom he is helping and who is helping him. The touch of science makes the whole world kin.

The history of the past gives us many examples of this brotherhood of science. In the revival of learning throughout the sixteenth and seventeenth centuries, and some way on into the eighteenth century, the common use of the Latin tongue made intercourse easy. In some respects, in those earlier days science was more cosmopolitan than it afterwards became. In spite of the difficulties and hardships of travel, the men of science of different lands again and again met each other face to face, heard with their ears, and saw with their eyes what their brethren had to say or to show. The Englishman took the long journey to Italy to study there; the Italian, the Frenchman, and the German wandered from one seat of learning to another; and many a man held a chair in a country not his own. There was help, too, as well as intercourse. The Royal Society of London took upon itself the task of publishing nearly all the works of the great Italian Malpighi, and the brilliant Lavoisier, two years before his own countrymen in their blind fury slew him, received from the same body the highest token which it could give of its esteem.

In these closing years of the nineteenth century this great need of mutual knowledge and of common action felt by men of science of different lands is being manifested in a special way. Though nowadays what is done anywhere is soon known everywhere, the news of a discovery being often flashed over the globe by telegraph, there is an increasing activity in the direction of organisation to promote international meetings and international co-operation. In almost every science inquirers from many lands now gather together at stated intervals in international congresses to discuss matters which they have in common at heart, and go away each one feeling strengthened by having met his brother. The desire that in the struggle to lay bare the secrets of Nature the least waste of human energy should be incurred is leading more and more to the concerted action of nations combining to attack problems the solution of which is difficult and costly. The determination of standards of measurement, magnetic surveys, the solution of great geodetic problems, the mapping of the heavens and of the earth—all these are being carried on by international organisations.

In this and in other countries men's minds have this long while past been greatly moved by the desire to make fresh efforts to pierce the dark secrets of the forbidding Antarctic regions. Belgium has just made a brave single-handed attempt; a private enterprise sailing from these shores is struggling there now, lost for the present to our view; and this year we in England and our brethren in Germany are, thanks to the promised aid of the respective Governments, and no less to private liberality, in which this Association takes its share, able to begin the preparation of carefully organised expeditions. That international amity of which I am speaking is illustrated by the fact that in this country and in that there is not only a great desire, but a firm purpose, to secure the fullest co-operation between the expeditions which will leave the two shores. If in this momentous attempt any rivalry be shown between the two nations, it will be for each a rivalry, not in forestalling, but in assisting the other. May I add that if the story of the past may seem to give our nation some claim to the seas as more peculiarly our own, that claim bespeaks a duty likewise peculiarly our own to leave no effort untried by which we may plumb the seas' yet unknown depths and trace their yet unknown shores? That claim, if it means anything, means that when nations are joining hands in the dangerous work of exploring the unknown South, the larger burden of the task should fall to Britain's share; it means that we in this country should see to it, and see to it at once, that the concerted Antarctic expedition, which in some two years or so will leave the shores of Germany, of England, and, perhaps, of other lands, should, so far as we are concerned, be so equipped and so sustained that the risk of failure and disaster may be made as small, and the

hope of being able, not merely to snatch a hurried glimpse of lands not yet seen, but to gather in with full hands a rich harvest of the facts which men not of one science only, but of many, long to know, as great as possible.

Another international scientific effort demands a word of notice. The need which every inquirer in science feels to know, and to know quickly, what his fellow-worker, wherever on the globe he may be carrying on his work or making known his results, has done or is doing, led some four years back to a proposal for carrying out by international co-operation a complete current index, issued promptly, of the scientific literature of the world. Though much labour in many lands has been spent upon the undertaking, the project is not yet an accomplished fact. Nor can this, perhaps, be wondered at, when the difficulties of the task are weighed. Difficulties of language, difficulties of driving in one team all the several sciences, which, like young horses, wish each to have its head free with leave to go its own way, difficulties mechanical and financial of press and post, difficulties raised by existing interests—these and yet other difficulties are obstacles not easy to be overcome. The most striking and the most encouraging features of the deliberations which have now been going on for three years have been the repeated expressions, coming not from this or that quarter only, but from almost all quarters, of an earnest desire that the effort should succeed, of a sincere belief in the good of international co-operation, and of a willingness to sink as far as possible individual interests for the sake of the common cause. In the face of such a spirit we may surely hope that the many difficulties will ultimately pass out of sight.

Perhaps, however, not the least notable fact of international co-operation in science is the proposal which has been made within the last two years that the leading academies of the world should, by representatives, meet at intervals to discuss questions in which the learned of all lands are interested. A month hence a preliminary meeting of this kind will be held at Wiesbaden; and it is at least probable that the closing year of that nineteenth century in which science has played so great a part may at Paris during the great World's Fair—which every friend, not of science only, but of humanity, trusts may not be put aside or even injured through any untoward event, and which promises to be an occasion, not of pleasurable sight-seeing only, but also, by its many international congresses, of international communing in the search for truth—witness the first select Witenagemote of the science of the world.

I make no apology for having thus touched on international co-operation. I should have been wanting, had I not done so, to the memorable occasion of this meeting. A hundred years ago two great nations were grappling with each other in a fierce struggle, which had lasted, with pauses, for many years, and was to last for many years to come; war was on every lip and in almost every heart. To-day this meeting has, by a common wish, been so arranged that those two nations should, in the persons of their men of science draw as near together as they can, with nothing but the narrow streak of the Channel between them, in order that they may take counsel together on matters in which they have one interest and a common hope. May we not look upon this brotherly meeting as one of many signs that science, though she works in a silent manner and in ways unseen by many, is steadily making for peace?

Looking back, then, in this last year of the eighteen hundreds, on the century which is drawing to its close, while we may see in the history of scientific inquiry much which, telling the man of science of his shortcomings and his weakness, bids him be humble, we see also much, perhaps more, which gives him hope. Hope is indeed one of the watchwords of science. In the latter-day writings of some who know not science, much may be read which shows that the writer is losing or has lost hope in the future of mankind. There are not a few of these; their repeated utterances make a sign of the times. Seeing in matters lying outside science few marks of progress and many tokens of decline or of decay, recognising in science its material benefits only, such men have thoughts of despair when they look forward to the times to come. But if there be any truth in what I have attempted to urge to-night, if the intellectual, if the moral influences of science are no less marked than her material benefits, if, moreover, that which she has done is but the earnest of that which she shall do, such men may pluck up courage and gather strength by laying hold of her garment. We men of science at least need not share their views or their fears. Our feet are set, not on the shifting sands of the opinions and of the fancies of the day, but on a solid foundation of verified truth, which by the labours of each succeeding age is made broader and more firm. To us the past is a thing to look back upon, not with regret, not as something which has been lost, never to be regained, but with content, as something whose influence is with us still, helping us on our further way. With us, indeed, the past points not to itself, but to the future; the golden age is in front of us, not behind us; that which we do know is a lamp whose brightest beams are shed into the unknown before us, showing us how much there is ahead and lighting up the way to reach it. We are confident in the advance because, as each one of us feels that any step forward which he may make is not ordered by himself alone and is not the result of his own sole efforts in the present, but is, and that in large measure, the outcome of the labours of others in the past, so each one of us has the sure and certain hope that as the past has helped him, so his efforts, be they great or be they small, will be a help to those to come.

## SECTION A.

### MATHEMATICS AND PHYSICS.

OPENING ADDRESS BY PROF. J. H. POYNTING, F.R.S., PRESIDENT OF THE SECTION.

THE members of this Section will, I am sure, desire me to give expression to the gratification that we all feel in the realisation of the scheme first proposed from this chair by Dr. Lodge, the scheme for the establishment of a National Physical Laboratory. It would be useless here to attempt to point out the importance of the step taken in the definite foundation of the Laboratory, for we all recognise that it was absolutely necessary for the due progress of physical research in this country. It is matter for congratulation that the initial guidance of the work of the Laboratory has been placed in such able hands.

While the investigation of nature is ever increasing our knowledge, and while each new discovery is a positive addition never again to be lost, the range of the investigation and the nature of the knowledge gained form the theme of endless discussion. And in this discussion, so different are the views of different schools of thought, that it might appear hopeless to look for general agreement, or to attempt to mark progress.

Nevertheless, I believe that in some directions there has been real progress, and that physicists, at least, are tending towards a general agreement as to the nature of the laws in which they embody their discoveries, of the explanations which they seek to give, and of the hypotheses they make in their search for explanations.

I propose to ask you to consider the terms of this agreement, and the form in which, as it appears to me, they should be drawn up.

The range of the physicist's study consists in the visible motions and other sensible changes of matter. The experiences with which he deals are the impressions on his senses, and his aim is to describe in the shortest possible way how his various senses have been, will be, or would be affected.

His method consists in finding out all likenesses, in classing together all similar events, and so giving an account as concise as possible of the motions and changes observed. His success in the search for likenesses and his striving after conciseness of description lead him to imagine such a constitution of things that likenesses exist even where they elude his observation, and he is thus enabled to simplify his classification on the assumption that the constitution thus imagined is a reality. He is enabled to predict on the assumption that the likenesses of the future will be the likenesses of the past.

His account of nature, then, is, as it is often termed, a descriptive account.

Were there no similarities in events, our account of them could not rise above a mere directory, with each individual event entered up separately with its address. But the similarities observed enable us to class large numbers of events together, to give general descriptions, and indeed to make, instead of a directory, a readable book of science, with laws as the headings of the chapters.

These laws are, I believe, in all cases brief descriptions of observed similarities. By way of illustration let us take two or three examples.

The law of gravitation states that to each portion of matter we can assign a constant—its mass—such that there is an acceleration towards it of other matter proportional to that mass divided by the square of its distance away. Or all bodies resemble each other in having this acceleration towards each other.

Hooke's law for the case of a stretched wire states that each successive equal small load produces an equal stretch, or states that the behaviour of the wire is similar for all equal small pulls.

Joule's law for the heat appearing when a current flows in a wire states that the rate of heat development is proportional to the square of the current multiplied by the resistance, or states that all the different cases resemble each other in having $H \div C^2Rt$ constant.

And, generally, when a law is expressed by an equation, that equation is a statement that two different sets of measurements are made, represented by the terms on the two sides of the equation, and that all the different cases resemble each other in that the two sets have the constant relation expressed by the equation. Accurate prediction is based on the assumption that when we have made the measurements on the one side of the equation we can tell the result of the measurements implied on the other side.

If this is a true account of the nature of physical laws, they have, we must confess, greatly fallen off in dignity. No long time ago they were quite commonly described as the Fixed Laws of Nature, and were supposed sufficient in themselves to govern the universe. Now we can only assign to them the humble rank of mere descriptions, often tentative, often erroneous, of similarities which we believe we have observed.

The old conception of laws as self-sufficing governors of nature was, no doubt, a survival of a much older conception of the scope of physical science, a mode of regarding physical phenomena which had itself passed away.

I imagine that originally man looked on himself and the result of his action in the motions and changes which he produced in matter, as the one type in terms of which he should seek to describe all motions and changes. Knowing that his purpose and will were followed by motions and changes in the matter about him, he thought of similar purpose and will behind all the motions and changes which he observed, however they occurred; and he believed, too, that it was necessary to think thus in giving any consistent account of his observations. Taking this anthropomorphic—or, shall we say, psychical—view, the laws he formulated were not merely descriptions of similarities of behaviour, but they were also expressions of fixed purpose and the resulting constancy of action. They were commands given to matter which it must obey.

The psychical method, the introduction of purpose and will, is still appropriate when we are concerned with living beings. Indeed, it is the only method which we attempt to follow when we are describing the motions of our fellow-creatures. No one seeks to describe the motions and actions of himself and of his fellow-men, and to classify them without any reference to the similarity of purpose when the actions are similar. But as the study of nature progressed, it was found to be quite futile to bring in the ideas of purpose and will when merely describing and classifying the motions and changes of non-living matter. Purpose and will could be entirely left out of sight, and yet the observed motions and changes could be described, and predictions could be made as to future motions and changes. Limiting the aim of physical science to such description and prediction, it gradually became clear that the method was adequate for the purpose, and over the range of non-living matter, at least, the psychical yielded to the physical. Laws ceased to be commands analogous to legal enactments, and became mere descriptions. But during the passage from one position to the other, by a confusion of thought which may appear strange to us now that we have finished the journey, though no doubt it was inevitable, the purpose and will of which the laws had been the expression were put into the laws themselves; they were personified and made to will and act.

Even now these early stages in the history of thought can be traced by survivals in our language, survivals due to the ascription of moral qualities to matter. Thus gases are still sometimes said to obey or to disobey Boyle's Law as if it were an enactment for their guidance, and as if it set forth an ideal, the perfect gas, for their imitation. We still hear language which seems to imply that real gases are wanting in perfection, in that they fail to observe the exact letter of the law. I suppose on this view we should have to say that hydrogen is nearest to perfection; but then we should have to regard it as righteous over-much, a sort of Pharisee among gases which overshoots the mark in its endeavour to obey the law. Oxygen and nitrogen we may regard as good enough in the affairs of everyday life. But carbon dioxide and chlorine and the like are poor sinners which yield to temptation and liquefy whenever circumstances press at all hardly on them.

There is a similar ascription of moral qualities when we judge bodies according to their fulfilment of the purpose for which we use them, when we describe them as good or bad radiators, good or bad insulators, as if it were a duty on their part to radiate well, or insulate well, and as if there were failures on the part of nature to come up to the proper standard.

These are of course mere trivialities, but the reaction of language on thought is so subtle and far-reaching that, risking the accusation of pedantry, I would urge the abolition of all such picturesque terms. In our quantitative estimates let us be content with "high" or "low," "great" or "small," and let us remember that there is no such thing as a failure to obey a physical law. A broken law is merely a false description.

Concurrently with the change in our conception of physical law has come a change in our conception of physical explanation. We have not to go very far back to find such a statement as this—that we have explained anything when we know the cause of it, or when we have found out the reason why—a statement which is only appropriate on the psychical view. Without entering into any discussion of the meaning of cause, we can at least assert that that meaning will only have true content when it is concerned with purpose and will. On the purely physical or descriptive view, the idea of cause is quite out of place. In description we are solely concerned with the "how" of things, and their "why" we purposely leave out of account. We explain an event, not when we know "why" it happened, but when we show "how" it is like something else happening elsewhere or otherwhen—when, in fact, we can include it as a case described by some law already set forth. In explanation, we do not account *for* the event, but we improve our account *of* it by likening it to what we already knew.

For instance, Newton explained the falling of a stone when he showed that its acceleration towards the earth was similar to and could be expressed by the same law as the acceleration of the moon towards the earth.

He explained the air disturbance we call "sound" when he showed that the motions and forces in the pressure waves were like motions and forces already studied.

Franklin explained lightning when and so far as he showed that it was similar in its behaviour to other electric discharges.

Here I do not fear any accusation of pedantry in joining those who urge that we should adapt our language to the modern view. It would be a very real gain, a great assistance to clear thinking, if we could entirely abolish the word "cause," in physical description, cease to say "why" things happen unless we wish to signify an antecedent purpose, and be content to own that our laws are but expressions of "how" they occur.

The aim of explanation, then, is to reduce the number of laws as far as possible, by showing that laws, at first separated, may be merged in one; to reduce the number of chapters in the book of science by showing that some are truly mere sub-sections of chapters already written.

To take an old but never-worn-out metaphor, the physicist is examining the garment of nature, learning of how many, or rather of how few, different kinds of thread it is woven, finding how each separate thread enters into the pattern, and seeking from the pattern woven in the past to know the pattern yet to come.

How many different kinds of thread does nature use?

So far, we have recognised some eight or nine, the number of different forms of energy which we are still obliged to count as distinct. But this distinction we cannot believe to be real. The relations between the different forms of energy, and the fixed rate of exchange when one form gives place to another, encourage us to suppose that if we could only sharpen our senses, or change our point of view, we could effect a still further reduction. We stand in front of nature's loom as we watch the weaving of the garment; while we follow a particular thread in the pattern it suddenly disappears, and a thread of another colour takes its place. Is this a new thread, or is it merely the old thread turned round and presenting a new face to us? We can do little more than guess. We cannot get to the other side of the pattern, and our minutest watching will not tell us all the working of the loom.

Leaving the metaphor, were we true physicists, and physicists alone, we should, I suppose, be content to describe merely what we observe in the changes of energy. We should say, for instance, that so much kinetic energy ceases, and that so much heat appears, or that so much light comes to a surface, and that so much chemical energy takes its place. But we have to take ourselves as we are, and reckon with the fact that though our material is physical, we ourselves are psychical. And, as a mere matter of fact, we are not content with such discontinuous descriptions. We dislike the discontinuity and we think of an underlying identity. We think of the heat as being that which a moment before was energy of visible motion, we think of the light as changing its form alone and becoming itself the chemical energy. Then to our passive dislike to discontinuity we join our active desire to form a mental picture of what may be going on, a picture like something which we already know. Coming on these discontinuities our ordinary method of explanation fails, for they are not obviously like those series of events in which we can trace every step. We then imagine a constitution of matter and modifications of it corresponding to the different kinds of energy, such that the discontinuities vanish, and such that we can picture one form of energy passing into another and yet keeping the same in kind throughout. We are no longer content to describe what we actually see or feel, but we describe what we imagine we should see or feel if our senses were on quite another scale of magnitude and sensibility. We cease to be physicists of the real and become physicists of the ideal.

To form such mental pictures we naturally choose the sense which makes such pictures most definite, the sense of sight, and think of a constitution of matter which shall enable us to explain all the various changes in terms of visible motions and accelerations. We imagine a mechanical constitution of the universe.

We are encouraged in this attempt by the fact that the relations in this mechanical conception can be so exactly stated, that the equations of motion are so very definite. We have, too, examples of mechanical systems, of which we can give accounts far exceeding in accuracy the accounts of other physical systems. Compare, for instance, the accuracy with which we can describe and foretell the path of a planet with our ignorance of the movements of the atmosphere as dependent on the heat of the sun. The planet keeps to the astronomer's time-table, but the wind still bloweth almost where it listeth.

The only foundation which has yet been imagined for this mechanical explanation—if we may use "explanation" to denote the likening of our imaginings to that which we actually observe—is the atomic and molecular hypothesis of matter. This hypothesis arose so early in the history of science that we are almost tempted to suppose that it is a necessity of thought, and that it has a warrant of some higher order than any other hypothesis which could be imagined. But I suspect that if we could trace its early development we should find that it arose in an attempt to explain the phenomena of expansion and contraction, evaporation and solution. Were matter a continuum we should have to admit all these as simple facts, inexplicable in that they are like nothing else. But imagine matter to consist of a crowd of separate particles with interspaces. Contraction and expansion are then merely a drawing in and a widening out of the crowd. Solution is merely the mingling of two crowds, and evaporation merely a dispersal from the outskirts. The most evident properties of matter are then similar to what may be observed in any public meeting.

For ages the molecular hypothesis hardly went further than this. The first step onward was the ascription of vibratory motion to the atoms to explain heat. Then definite qualities were ascribed, definite mutual forces were called into play to explain elasticity and other properties or qualities of matter. But I imagine its first really great achievement was its success in explaining the law of combining proportions, and next to that we should put its success in explaining many of the properties of gases.

While light was regarded as corpuscular—in fact molecular, and while direct action at a distance presented no difficulty, the molecular hypothesis served as the one foundation for the mechanical representation of phenomena. But when it was shown that infinitely the best account of the phenomena of light could be given on the supposition that it consisted of waves, something was needed, as Lord Salisbury has said, to wave, both in the interstellar and in the intermolecular spaces. So the hypothesis of an ether was developed, a necessary complement of that form of the molecular hypothesis in which matter consists of discrete particles with matter-free intervening spaces.

Then Faraday's discovery of the influence of the dielectric medium in electric actions led to the general abandonment of the idea of action at a distance, and the ether was called in to aid matter in the explanation of electric and magnetic phenomena. The discovery that the velocity of electro-magnetic waves is the same as that of light-waves is at least circumstantial evidence that the same medium transmits both.

I suppose we all hope that some time we shall succeed in attributing to this medium such further qualities that it will be able to enlarge its scope and take in the work of gravitation.

The mechanical hypothesis has not always taken this dualistic form of material atoms and molecules, floating in a quite distinct ether. I think we may regard Boscovich's theory of point-centres surrounded by infinitely extending atmospheres of force as really an attempt to get rid of the dualism, and Faraday's theory of point centres with radiating lines of force is only Boscovich's theory in another form. But Lord Kelvin's vortex-atom theory gives us a simplification more easily thought of. Here all space is filled with continuous fluid—shall we say a fluid ether?—and the atoms are mere loci of a particular type of motion of this frictionless fluid. The sole differences in the atoms are differences of position and motion. Where there are whirls, we call the fluid matter; where there are no whirls, we call it ether. All energy is energy of motion. Our visible kinetic energy, $MV^2/2$, is energy in and round the central whirls; our visible energy of position, our potential energy, is energy of motion in the outlying regions.

A similar simplification is given by Dr. Larmor's hypothesis, in which, again, all space is filled with continuous substance all of one kind, but this time solid rather than fluid. The atoms are loci of strain instead of whirls, and the ether is that which is strained.

So, as we watch the weaving of the garment of nature, we resolve it in imagination into threads of ether spangled over with beads of matter. We look still closer, and the beads of matter vanish; they are mere knots and loops in the threads of ether.

The question now faces us—How are we to regard these hypotheses as to the constitution of matter and the connecting ether? How are we to look upon the explanations they afford? Are we to put atoms and ether on an equal footing with the phenomena observed by our senses, as truths to be investigated for their own sake? Or are they mere tools in the search for truth, liable to be worn out or superseded?

That matter is grained in structure is hardly more than an expression of the fact that in very thin layers it ceases to behave as in thicker layers. But when we pass on from this general statement and give definite form to the granules, or assume definite qualities to the intergranular cement, we are dealing with pure hypotheses.

It is hardly possible to think that we shall ever see an atom or handle the ether. We make no attempt whatever to render them evident to the senses. We connect observed conditions and changes in gross visible matter by invisible molecular and ethereal machinery. The changes at each end of the machinery of which we seek to give an account are in gross matter, and this gross matter is our only instrument of detection, and we never receive direct sense-impressions of the imagined atoms or the intervening ether. To strictly descriptive physicists their only use and interest would lie in their service in prediction of the changes which are to take place in gross matter.

It appears quite possible that various types of machinery might be devised to produce the known effects. The type we have adopted is undergoing constant minor changes, as new discoveries suggest new arrangements of the parts. Is it utterly beyond possibility that the type itself should change?

The special molecular and ethereal machinery which we have designed, and which we now generally use, has been designed because our most highly developed sense is our sense of sight. Were we otherwise, had we a sense more delicate than sight, one affording us material for more definite mental presentation, we might quite possibly have constructed very different hypotheses. Though, as we are, we cannot conceive any higher type than that founded on the sense of sight, we can imagine a lower type, and by way of illustration of the point let us take the sense of which my predecessor spoke last year—the sense of smell. In us it is very undeveloped. But let us imagine a

being in whom it is highly cultivated, say a very intellectual and very hypothetical dog. Let us suppose that he tries to frame an hypothesis as to light. Having found that his sense of smell is excited by surface exhalations, will he not naturally make and be content with a corpuscular theory of light? When he has discovered the facts of dispersion, will he not think of the different colours as different kinds of smell—insensible, perhaps, to him, but sensible to a still more highly gifted, still more hypothetical, dog?

Of course, with our superior intellect and sensibility, we can see where his hypothesis would break down; but unless we are to assume that we have reached finality in sense development, the illustration, grotesque as it may be, will serve to show that our hypotheses are in terms of ourselves rather than in terms of nature itself, they are ejective rather than objective, and so they are to be regarded as instruments, tools, apparatus only to aid us in the search for truth.

To use an old analogy—and here we can hardly go except upon analogy—while the building of nature is growing spontaneously from within, the model of it, which we seek to construct in our descriptive science, can only be constructed by means of scaffolding from without, a scaffolding of hypotheses. While in the real building all is continuous, in our model there are detached parts which must be connected with the rest by temporary ladders and passages, or which must be supported till we can see how to fill in the understructure. To give the hypotheses equal validity with facts is to confuse the temporary scaffolding with the building itself.

But even if we take this view of the temporary nature of our molecular and ethereal imaginings, it does not lessen their value, their necessity to us.

It is merely a true description of ourselves to say that we must believe in the continuity of physical processes, and that we must attempt to form mental pictures of those processes the details of which elude our observation. For such pictures we must frame hypotheses, and we have to use the best material at command in framing them. At present there is only one fundamental hypothesis—the molecular and ethereal hypothesis—in some such form as is generally accepted.

Even if we take the position that the form of the hypothesis may change as our knowledge extends, that we may be able to devise new machinery—nay, even that we may be able to design some quite new type to bring about the same ends—that does not appear to me to lessen the present value of the hypothesis. We can recognise to the full how well it enables us to group together large masses of facts which, without it, would be scattered apart, how it serves to give working explanations, and continually enables investigators to think out new questions for research. We can recognise that it is the symbolical form in which much actual knowledge is cast. We might almost as well quarrel with the use of the letters of the alphabet, inasmuch as they are not the sounds themselves, but mere arbitrary symbols of the sounds.

In this country there is no need for any defence of the use of the molecular hypothesis. But abroad the movement from the position in which hypothesis is confounded with observed truth has carried many through the position of equilibrium equally far on the other side, and a party has been formed which totally abstains from molecules as a protest against immoderate indulgence in their use. Time will show whether these protesters can do without any hypothesis, whether they can build without scaffolding or ladders. I fear that it is only an attempt to build from balloons.

But the protest will have value if it will put us on our guard against using molecules and the ether everywhere and everywhere. There is, I think, some danger that we may get so accustomed to picturing everything in terms of these hypotheses that we may come to suppose that we have no firm basis for the facts of observation until we have given a molecular account of them, that a molecular basis is a firmer foundation than direct experience.

Let me illustrate this kind of danger. The phenomena of capillarity can, for the most part, be explained on the assumption of a liquid surface tension. But if the subject is treated merely from this point of view, it stands alone—it is a portion of the building of science hanging in the air. The molecular hypothesis then comes in to give some explanation of the surface tension, gives, as it were, a supporting understructure connecting capillarity with other classes of phenomena. But here, I think, the hypothesis should stop, and such phenomena as can be explained by the surface tension should be so explained without reference to molecules. They should not be brought in again till the surface-tension explanation fails. It is necessary to bear in mind what part is scaffolding, and what is the building itself, already firm and complete.

Or, as another illustration, take the Second Law of Thermodynamics. I suspect that it is sometimes supposed that a molecular theory from which the Second Law could be deduced would be a better basis for it than the direct experience on which it was founded by Clausius and Kelvin, or that the mere imagining of a Maxwell's sorting demon has already disproved the universality of the law; whereas he is a mere hypothesis grafted on a hypothesis, and nothing corresponding to his action has yet been found.

There is more serious danger of confusion of hypothesis with fact in the use of the ether: more risk of failure to see what is accomplished by its aid. In giving an account of light, for instance, the right course, it appears to me, is to describe the phenomena and lay down the laws under which they are grouped, leaving it an open question what it is that waves, until the phenomena oblige us to introduce something more than matter, until we see what properties we must assign to the ether, properties not possessed by matter, in order that it may be competent to afford the explanations we seek. We should then realise more clearly that it is the constitution of matter which we have imagined, the hypothesis of discrete particles which obliges us to assume an intervening medium to carry on the disturbance from particle to particle. But the vortex-atom hypothesis and Dr. Larmor's strain-atom hypothesis both seem to indicate that we are moving in the direction of the abolition of the distinction between matter and ether, that we shall come to regard the luminiferous medium, not as an attenuated substance here and there encumbered with detached blocks—the molecules of matter—but as something which in certain places exhibits modifications which we term matter. Or starting rather from matter, we may come to think of matter as no longer consisting of separated granules, but as a continuum with properties grouped round the centres, which we regard as atoms or molecules.

Perhaps I may illustrate the danger in the use of the conception of the ether by considering the common way of describing the electro-magnetic waves, which are all about us here, as ether waves. Now in all cases with which we are acquainted, these waves start from matter; their energy before starting was, as far as we can guess, energy of the matter between the different parts of the source, and they manifest themselves in the receiver as energy of matter. As they travel through the air, I believe that it is quite possible that the electric energy can be expressed in terms of the molecules of air in their path, that they are effecting atomic separations as they go. If so, then the air is quite as much concerned in their propagation as the ether between its molecules. In any case, to term them ether waves is to prejudge the question before we have sufficient evidence.

Unless we bear in mind the hypothetical character of our mechanical conception of things, we may run some risk of another danger—the danger of supposing that we have something more real in mechanical than in other measurements. For instance, there is some risk that the work measure of specific heat should be regarded as more fundamental than the heat measure, in that heat is truly a "mode of motion." On the molecular hypothesis, heat is no doubt a mixture of kinetic energy and potential energy of the molecules and their constituents, and may even be entirely kinetic energy; and we may conceivably in the future make the hypothesis so definite that, when we heat a gramme of water 1°, we can assign such a fraction of an erg to each atom. But look how much pure hypothesis is here. The real superiority of the work measure of specific heat lies in the fact that it is independent of any particular substance, and there is nothing whatever hypothetical about it.[1]

[1] This risk of imagining one particular kind of measure more real than another, more in accordance with the truth of things, may be further illustrated by the common idea that mass-acceleration is the only way to measure a force. We stand apart from our mechanical system and watch the motions and the accelerations of the various parts, and we find that mass-accelerations have a certain significance in our system. If we keep ourselves outside the system and only use our sense of sight, then mass-acceleration is the only way of describing that behaviour of one body in the presence of others which we term force on it. But if we go about in the system and pull and push bodies, we find that there is another conception of force, in which another sense than sight is concerned—another mode

Another illustration of the illegitimate use of our hypothesis, as it appears to me, is in the attempt to find in the ether a fixed datum for the measurement of material velocities and accelerations, a something in which we can draw our coordinate axes so that they will never turn or bend. But this is as if, discontented with the movement of the earth's pole, we should seek to find our zero lines of latitude and longitude in the Atlantic Ocean. Leaving out of sight the possibility of ethereal currents which we cannot detect, and the motions due to every ray of light which traverses space, we could only fix positions and directions in the ether by buoying them with matter. We know nothing of the ether, except by its effects on matter, and, after all, it would be the material buoys which would fix the positions and not the ether in which they float.

The discussion of the physical method, with its descriptive laws and explanations, and its hypothetical extension of description, leads us on to the consideration of the limitation of its range. The method was developed in the study of matter which we describe as non-living, and with non-living matter the method has sufficed for the particular purposes of the physicist. Of course only a little corner of the universe has been explored, but in the study of non-living matter we have come to no impassable gulfs, no chasms across which we cannot throw bridges of hypothesis. Does the method equally suffice when it is applied to living matter? Can we give a purely physical account of such matter, likening its motions and changes to other motions and changes already observed, and so explaining them? Can we group them in laws which will enable us to predict future conditions and positions? The ancient question never answered, but never ceasing to press for an answer.

Having faith in our descriptive method, let us use it to describe our real attitude on the question. Do we, or do we not, as a matter of fact, make any attempt to apply the physical method to describe and explain those motions of matter which on the psychical view we term voluntary?

Any commonplace example, and the more commonplace the more is it to the point, will at once tell us our practice, whatever may be our theory. For instance, a steamer is going across the Channel. We can give a fairly good physical account of the motion of the steamer. We can describe how the energy stored in the coal passes out through the boiler into the machinery, and how it is ultimately absorbed by the sea. And the machinery once started, we can give an account of the actions and reactions between its various parts and the water, and if only the crew will not interfere, we can predict with some approach to correctness how the vessel will run. All these processes can be likened to processes already studied—perhaps on another scale—in our laboratories, and from the similarities prediction is possible. But now think of a passenger on board who has received an invitation to take the journey. It is simply a matter of fact that we make no attempt at a complete physical account and explanation of those actions which he takes to accomplish his purpose. We trace no lines of induction in the ether connecting him with his friends acrcss the Channel, we seek no law of force under which he moves. In practice the strictest physicist abandons the physical view, and replaces it by the psychical. He admits the study of purpose as well as the study of motion.

He has to admit that here his physical method of prediction fails. In physical observations one set of measurements may lead to the prediction of the results of another set of measurements. The equations expressing the laws imply different observations with some definite relation between their results, and if we know one set of observations and that definite relation we can predict the result of the other set. But if we take the psychical view of actions, we can only measure the actions. We have no independent means of studying and measuring the motions which preceded the actions, we can only estimate their value by the consequent actions. If we formed equations, they would be mere identities with the same terms on either side.

The consistent and persistent physicist, finding the door closed against him, finding that he has hardly a sphere of influence left to him in the psychical region, seeks to apply his methods in another way by assuming that if he knew all about the molecular positions and motions in the living matter, then the ordinary physical laws could be applied and the physical conditions at any future time could be predicted. He would say, I suppose, with regard to the Channel passenger, that it is absurd to begin with the most complicated mechanism, and seek to give a physical account of that. He would urge that we should take some lower form of life where the structure and motions are simpler, and apply the physical methods to that.

of measurement much more ancient and still far more extensively used —the measurement by weight supported. Each method has its own range; each is fundamental in that range. It is one of the great practical problems n physics to make the pendulum give us the exact ratio of the units in the wo systems.

Well, then, let us look for the physical explanation of any motion which we are entitled from its likeness to our own action to call a voluntary motion. Must we not own that even the very beginning of such explanation is as yet non-existent? It appears to me that the assumption that our methods do apply, and that purely physical explanation will suffice to predict all motions and changes, voluntary and involuntary, is at present simply a gigantic extra-polation, which we should unhesitatingly reject if it were merely a case of ordinary physical investigation. The physicist when thus extending his range is ceasing to be a physicist, ceasing to be content with his descriptive methods in his intense desire to show that he is a physicist throughout.

Of course we may describe the motions and changes of any type of matter after the event, and in a purely physical manner. And as Prof. Ward has suggested, in a most important contribution to this subject which he has made in his recently published "Gifford Lectures" ("Naturalism and Agnosticism," *The Gifford Lectures*, 1896–98, vol. ii. p. 71), where ordinary physical explanations fail to give an account of the motions, we might imagine some structure in the ether, and such stresses between the ether and matter that our physical explanations should still hold. But, as Prof. Ward says, such ethereal constructions would present no warrant for their reality or consistency. Indeed they would be mere images in the surface of things to account for what goes on in front of the surface, and would have no more reality than the images of objects in a glass.

If we have full confidence in the descriptive method, as applied to living and non-living matter, it appears to me that up to the present it teaches us that while in non-living matter we can always find similarities, that, while each event is like other events, actual or imagined, in a living being there are always dissimilarities. Taking the psychical view—the only view which we really do at present take—in the living being there is always some individuality, something different from any other living being, and full prediction in the physical sense, and by physical methods, is impossible. If this be true, the loom of nature is weaving a pattern with no mere geometrical design. The threads of life, coming in we know not where, now twining together, now dividing, are weaving patterns of their own, ever increasing in intricacy, ever gaining in beauty.

## SECTION B.

### CHEMISTRY.

OPENING ADDRESS BY DR. HORACE T. BROWN, F.R.S., PRESIDENT OF THE SECTION.

THE subject which I have chosen for my Address is the fixation of carbon by plants, one which is the common meeting ground of chemistry, physics and biology. I must, however, confine myself only to certain aspects of the question, since it is manifestly impossible to fully discuss the whole of a subject of such magnitude and importance within the time at my disposal.

We have become so accustomed to the idea that the higher plants derive *the whole* of their carbon from atmospheric sources that we are apt to forget how very indirect is the nature of much of the experimental evidence on which this belief is founded. There can, of course, be no doubt that the primary source of the organic carbon of the soil, and of the plants growing on it, is the atmosphere; but of late years there has been such an accumulation of evidence tending to show that the higher plants are capable of being nourished by the direct application of a great variety of ready-formed organic compounds, that we are justified in demanding further proof that the stores of organic substances in the soil must necessarily be oxidised down to the lowest possible point before their carbon is once more in a fit state to be assimilated.

It was the hope of gaining more direct evidence on this important question which led me some time ago to attack the problem experimentally in conjunction with Mr. F. Escombe, the resources of the Jodrell Laboratory at Kew having been

kindly put at our disposal by Sir W. Thiselton-Dyer and Dr. D. H. Scott. Up to the present time our experiments have not been carried far enough to enable us to give a positive answer to the main question, but they have already suggested a new method of attack which will enable us in the future to determine, with a fair amount of certainty, whether any particular plant, growing under perfectly natural conditions, derives any appreciable portion of its carbon from any other source than the gaseous carbon dioxide of the atmosphere.

During the course of the inquiry, many interesting side issues have been raised which we believe to be of some importance in their bearing on the processes of plant nutrition, and it is to a consideration of these that I intend to devote the greater part of my Address.

I must, however, in the first place indulge in a little historical retrospect, and am the more tempted to do this, as far as the early pioneers in this branch of knowledge are concerned, since a critical study of their writings has shown me very clearly that the relative merits of some of these older workers, and the respective parts which they took in founding the true theory of assimilation, have in our own time been much misrepresented by more than one historian of science whose name carries great weight.

There is no chapter in the history of scientific discovery of greater abiding interest than that which was opened by Priestley in 1771, when he commenced his work on the influence of plants on the composition of the air around them. It has often been assumed that these experiments of Priestley, which were unquestionably the starting-point for all succeeding workers, were the result of some haphazard method of working, and of one of those happy chances to which he is in the habit of attributing some of his most important discoveries. However much the element of chance entered into some of his work, and in this respect I think Priestley often does himself injustice, the discovery of the amelioration of vitiated air by plants was certainly not a case of this kind. Of all his contemporaries belonging to the old school of chemistry, Priestley had the clearest conception of the processes of animal respiration and of their identity with the process of combustion. This is clearly shown by his "Observations on Respiration and the Use of the Blood," which he presented to the Royal Society in 1776 This memoir, written of course from the phlogistic point of view, only requires translating into the language of the newer chemistry to be an accurate statement of the main facts of animal respiration. We have it on Priestley's own authority that it was these studies which produced in his mind a conviction that there must be some provision in nature for dephlogisticating the air which was constantly being vitiated by the processes of respiration, combustion and putrefaction, and for rendering it once more fit for maintaining animal life. In his search for this compensating influence, which he justly regarded as one of the most important problems of natural philosophy, he made many attempts to bring back the vitiated air to its original state by agitating it with water, and by submitting it to the continued action of light and heat, and it was in the course of these systematic attempts that he was led to study the influence of plants in this direction.

It was in the month of August 1771 that he made the memorable experiments at Leeds of immersing sprigs of mint in air which had been vitiated by the burning of a candle or by animal respiration. To quote his own words, this observation led him "to conclude that plants, instead of affecting the air in the same manner with animal respiration, reverse the effects of breathing, and tend to keep the atmosphere sweet and wholesome when it is become noxious in consequence of animals either living or breathing, or dying and putrefying in it." That he was fully convinced that these observations, which he repeated and amplified in the following year. presented the true key to the problem, is sufficiently shown by another passage in which he says: "These proofs of the partial restoration of air by plants in a state of vegetation, though in a confined and unnatural situation, cannot but render it highly probable that the injury which is continually done to the atmosphere by the respiration of such a number of animals, and the putrefaction of such masses of both vegetable and animal matter, is, in part at least, repaired by the vegetable creation; and notwithstanding the prodigious mass of air that is corrupted daily by the above causes, yet if we consider the immense profusion of vegetables upon the face of the earth growing in places suited to their nature, and consequently at full liberty to exert all their powers, both inhaling and exhaling, it can hardly be thought but that it may be a sufficient counterbalance to it, and that the remedy is adequate to the evil."

Between the time of Priestley temporarily relinquishing his experiments in this direction in 1772 and his resumption of them in 1778, owing to the adverse criticism of Scheele and others, he had discovered dephlogisticated air or oxygen, and had elaborated his method for ascertaining the purity of air, or its richness in oxygen, by determining its diminution in volume after mixing with an excess of nitric oxide over water.[1] This method gave, of course, a much greater degree of precision to his results than was attainable in his earlier work, where the purity of the air at the end of an experiment was only determined by ascertaining if it would support the combustion of a candle or allow a small animal to live in it.

The results of his later work were published in 1779, and were not altogether confirmatory of those arrived at six years before. It is true that he generally found evidence of an evolution of oxygen by the plants, but occasionally the air was less "pure" at the end of an experiment than it was at the beginning, and this occurred in a sufficient number of cases to Dr. Priestley to doubt to some extent the accuracy of his previous conclusions. On the whole, however, he still thinks it *probable* that the vegetation of healthy plants has a salutary effect on the air in which they grow.

The reason for this want of complete consistency in these later experiments was, of course, his failure at that time to recognise the important influence of *light* in bringing about the evolution of oxygen, an explanation which was given shortly afterwards by Ingen-Housz.

Priestley's attention was now taken up with another observation, which led him within a very short distance indeed of the discovery that the evolution of oxygen by plants is conditioned, not only by a sufficient degree of illumination, but also by the pre-existence of carbon dioxide. It is the more necessary to treat of this point somewhat in detail, since it is a part of his work which has received but scanty justice at the hands of recent writers, who have apparently failed to see how much our modern conceptions of plant nutrition really owe to the initiative of Priestley. In his "History of Botany," Sachs deals very unfairly with Priestley in this respect, owing to a want of intimate knowledge of his writings, and to the lack of anything like perspective in estimating the relative merits of his contemporaries Ingen-Housz and Senebier, whose position can only be completely understood after a careful study of their numerous original memoirs, some of which are by no means readily accessible.

In the course of his experiments on plants partially immersed in water more or less fully impregnated with "fixed air," Priestley had observed a fact which had not escaped the notice of Bonnet at an earlier date, that bubbles of gas arose spontaneously from the leaves and stems, and it occurred to him that an examination of the nature of this gas by means of his new eudiometric process ought to settle the question whether plants really do contribute in any way to the purification of ordinary air. It was in June 1778 that he put this to the test, and he found that the air thus liberated was much richer in oxygen than ordinary air. On removing the plants, he found to his astonishment that the water in which they had been placed, and which had a considerable amount of "green matter" adhering to the sides of the phials, still continued to evolve a gas which increased in amount when the vessels were placed in sunlight. On testing this gas with his eudiometric process, he found that it consisted to a great extent of "dephlogisticated air" or oxygen; in fact, from the experimental results which he gives it is evident that the gas contained from 74 to 85 per cent. of oxygen. Having observed that the "green matter" appeared much more readily in pump water than in rain or river water, and knowing that pump water contained considerable amounts of "fixed air," he was led to make a series of experiments with water artificially impregnated with carbon dioxide, which left no doubt in his mind that the production of the "green matter," and the evolution of the dephlogisticated air were in some way due to the presence of "fixed air." Up to this point Priestley was following a path which seemed about to lead him to a complete solution of his previous difficulties. He had beyond all question succeeded in showing that the evolution of oxygen was not only dependent on the pre-existence of carbon dioxide, but that light was also required

[1] Nitric oxide was discovered by Priestley in 1772, and was described by him under the name of "nitrous air."

for the process. It only wanted, in fact, the recognition of the vegetable nature of the alga which constituted his "green substance" to bring these observations into line with his previous work, and to complete a discovery which would have eclipsed in importance all the others with which Priestley's name is associated. It was just this one step which he most provokingly failed to take. It is true that he examined the "green substance" under the microscope, but owing to want of skill in the use of the instrument, and also to his defective eyesight, he was unable to determine its true nature, and unfortunately adopted the view that it had merely a mechanical action in separating the oxygen from the water, and, to use his own words, that "it was only a circumstance preceding the spontaneous emission of the air from water." He was, in fact, now inclined to regard the process as a purely chemical one, due to the direct action of light on the carbon dioxide dissolved in the water.

But this was by no means Priestley's final view, as shown by a further description of his experiments on plants set forth in the new edition of his works published in 1790, where he clearly recognised the error into which he had been led.[1] Meanwhile the subject had been taken up by two other observers, Ingen-Housz and Senebier, and in order to thoroughly understand the respective shares which these men took in advancing our knowledge of the assimilatory process, it is necessary to consult, not only their books, but also the numerous scattered memoirs which appeared at intervals between the years 1779 and 1800.

To Ingen-Housz must unquestionably be awarded the merit of having experimentally demonstrated that the amelioration of the surrounding air by plants is not, as Priestley at first believed, due to vegetative action *per se*, but is dependent on the access of light of a sufficient degree of intensity, and, moreover, that the power is confined to the green parts of the plants. At the same time, whilst recognising, as Priestley had done before him, that the combined action of plants and light on the air was a dephlogisticating process, he did not know, until after its demonstration by Senebier, that the particular form of phlogisticated air which was essential to plants was "fixed air" or carbon dioxide. In fact, Ingen-Housz had but a slender knowledge of the chemistry of his day, so much so indeed that he constantly confuses "phlogisticated air" or nitrogen with "fixed air," and attributes the source of the evolved oxygen either to air imprisoned within the leaf, or, in the case of submerged plants, to a metamorphosis of the water itself. I must, however, recall the fact that Ingen-Housz was the first to show that the green parts of plants in the dark, and the roots both in the light and in darkness, vitiate the air in the same way as animals do. On the strength of these experiments, he is generally given credit for having first observed the true respiration of plants, but I cannot avoid the conclusion that, in the controversy which ensued on this point between Ingen-Housz and Senebier, the adverse criticisms of the latter were well-founded. Whilst not denying that plants in the dark have some mephitic influence on the air around them, Senebier maintained that the greater part of the observed effect was due to a fermentative action set up in the large bulk of leaves which Ingen-Housz employed. Certainly some of the results appear to be largely in excess of those we should now expect to obtain from respiratory processes only.[2]

Senebier's work falls between the years 1782 and 1800. The fact that he was an early convert to the new ideas and generalisations of Lavoisier gives his views on plant nutrition far greater precision than those of Priestley and Ingen-Housz. His experiments, for the most part well devised, proved beyond all doubt that the oxygen disengaged from submerged and isolated plants could not be derived from air contained in the leaf parenchyma, but that it depended on the pre-existence of carbon dioxide, and that its evolution was strictly proportional to the amount of carbon dioxide which the water contained.

Although positive experimental proof was still wanting that aërial plants also derive their carbon from carbon dioxide, Senebier regarded this as extremely probable; but, taking into consideration the small amount of this gas present in the atmosphere, he concluded that it must reach the plant by the roots and leaves entirely in a state of solution in water.

The work of Priestley, Senebier, and Ingen-Housz fortunately attracted the attention of a young chemist of high attainments, who, within a period of less than ten years, did more for the advancement of vegetable physiology than any single observer before or since his time. Théodore de Saussure, the second of that illustrious name, and the son of the famous explorer and natural philosopher, commenced his researches about the year 1796, and in 1804 published his "Recherches Chimiques sur la Végétation," a modest little octavo volume of some 300 pages which must certainly take rank as one of the great classics of scientific literature, and one of the most remarkable books of the century.

De Saussure was a past master in the art of experiment, and the methods which he devised for demonstrating the influence of water, air and soil on vegetation have been the models on which all such investigations have been conducted ever since. It is indeed very difficult, when reading this masterly essay, to bear in mind that it was not written fifty or sixty years later than the date on its title-page, so essentially modern are its modes of expression and reasoning, and so far is the author in advance of his contemporaries. It is to this work we must refer for the first experimental proof that plants derive at any rate the greater part of their carbon from the surrounding atmosphere. This was shown by De Saussure by a variety of quantitative experiments of a sufficient degree of accuracy to bring out the great leading facts. By making known mixtures of carbon dioxide and air, and submitting them to the action of plants in sunlight, he was able, not only to show that the gaseous carbon dioxide was decomposed and the carbon assimilated, but also that the volume of oxygen disengaged was approximately equal to that of the carbon dioxide decomposed.[1] He also showed that plants growing in the open in moist sand, or in distilled water, and therefore under conditions in which they could not derive any carbon from other than atmospheric sources, not only materially increased in dry weight, but contained much more carbon at the close of the experiment than at the beginning, and had also fixed an appreciable amount of water in the process. That atmospheric carbon dioxide is not only beneficial to plants in sunlight, but is also essential to their very existence, De Saussure proved by introducing an absorbent of this gas into the vessel containing a plant or the branch of a tree rooted naturally in the soil. Under these conditions, the portions of the plant enclosed always died. He also ascertained by experiment the increase in dry weight of a sunflower plant during four months of natural growth; and knowing approximately the amount of water transpired during that period, and the maximum amount of solids which this transpired water could possibly introduce into the plant, he calculated that these solids, and the carbon dioxide in solution in the transpiration water, fell far short of accounting for the observed increase in the dry weight of the plant. This increase must, therefore, be mainly due to the fixation of atmospheric carbon dioxide and water.

It is certainly a remarkable fact that the rigid experimental proofs which De Saussure brought forward in support of his views did not carry conviction to the minds of every one. His book, however, suffered the fate of many others which have appeared in advance of their time. It is true that De Saussure's doctrines were always kept alive by the advanced physiologists of the French school, such as De Candolle and Dutrochet, but when Liebig first turned his attention to the subject he found the field in possession of the humus theory of Treviranus, a theory which no longer took any account of the decomposition of carbon dioxide by the leaves, but which de-

[1] The view which was taken by Priestley's contemporaries of his position with regard to the discovery of the fundamental facts is well exemplified by the following remarks taken from a paper published by Ingen-Housz in 1784 (*Annales de Physique*, xxiv. 44). "C'est à M. Priestley seul que nous devons la grande découverte que les végétaux possèdent le pouvoir de corriger l'air mauvais et d'ameliorer l'air commun: c'est lui qui nous en a ouvert la porte. J'ai été assez constamment attaché à ce beau système, dans le temps que lui même, par trop peu de prédilection pour ses propres opinions, paroissoit chanceler."

[2] It is by no means uncommon to find Ingen-Housz put forward as the discoverer of the fixation of carbon by plants from carbon dioxide. This claim is generally based on certain statements made in his essay on the "Food Plants and the Renovation of the Soil," published in 1796 as an appendix to the outlines of the fifteenth chapter of the "Proposed General Report from the Board of Agriculture." All that is good and sound in this essay is taken from Senebier's papers without any acknowledgment, but, in appropriating ideas which he evidently understands very imperfectly, he has built up a system of plant economy which is almost unintelligible.

[1] Although clearly indicating that no change of volume occurred in the mixture of air and carbon dioxide so treated, his final analytical results show a small apparent evolution of nitrogen. This was due to the eudiometric methods he employed, methods, it is true, far superior in point of accuracy to those of his predecessors, but still necessarily imperfect.

rived the whole of the elements of the growing plant from a solution of the soil extract taken up by the roots. We may well say with Sachs, "nothing can be conceived more deplorable than this theory of nutrition; it would have been bad at the end of the seventeenth century, it is difficult to believe that it could have been published thirty years after De Saussure's work." It is well known how by the cogency of his reasoning and the force of his genius Liebig successfully overthrew this heresy, and once more established the doctrine of carbon assimilation as taught by De Saussure; and the accurate work of Boussingault, who, whilst elaborating far more delicate analytical processes than were possessed by chemists in the early days of the century, still in the main used De Saussure's methods, gave the final death-blow to the humus theory, at any rate in the crude form in which it was presented by its originators. No one since that time has questioned the fact that green plants owe the greater part of their carbon to atmospheric sources, and the accumulated experience of two succeeding generations of workers has added proof on proof of the correctness of this great generalisation.

But whilst it cannot be doubted that green plants devoid of parasitic or saprophytic habit derive the principal part of their carbon from the air, is the experimental evidence at present so complete as to exclude all other sources of supply? De Saussure himself certainly left the door open to such a possibility, and although Boussingault held a different view, we find Sachs as late as 1865 maintaining that it is not contrary to the generally accepted theory of assimilation to suppose that there are chlorophyllous plants which decompose carbon dioxide and at the same time absorb ready-formed organic substances whose carbon they utilise in the formation of new organs.

Up to comparatively recently there was little or no experimental evidence to justify this supposition, for the early experiments of De Saussure on the influence of solutions of sugar, and of other organic substances, on growing plants, although very suggestive, were not of a sufficiently precise nature to lead to any conclusions, and we must come down to within fifteen years of the present time for anything like a demonstration that the green organs of plants can, under favourable conditions, build up their tissue from already elaborated carbon compounds just as do the fungi and the non-chlorophyllous plants generally.

The active centres of the decomposition of carbon dioxide in green leaves are the chlorophyll corpuscles or chloroplastids, and the first visible indication of this decomposition is the formation within these chloroplastids of minute granules of starch whose presence can be shown by suitable micro-chemical means. I have elsewhere discussed the question of how far the appearance of this starch is dependent on the pre-existence of other carbohydrates of a simpler constitution, and also the probability that the whole of the products of assimilation do not necessarily pass through the form of starch: this is a subject which need scarcely concern us at the present moment; it is sufficient to draw attention to the main fact that in an assimilating cell the chloroplastids, in the vast majority of cases, give rise to these minute starch granules, which once more disappear when the plant is placed in darkness, or when the air around it is deprived of carbon dioxide. Now in 1883 Böhm made the interesting discovery that when green leaves are placed in the dark until the starch of their chloroplastids has completely disappeared, there is a reappearance of starch when the cut end of the leaf-stalk is immersed in a solution of cane sugar and of dextrose, or when the leaf is brought directly in contact with solutions of these substances. He found, in fact, that the elements of the cell which, under ordinary circumstances, manufacture their materials for plant growth by the reduction of carbon dioxide under the influence of sunlight, can, under other conditions, supply their requirements from suitable ready-formed organic substances. These observations of Böhm were fully confirmed two years later by Schimper, and were subsequently much extended by A. Meyer and E. Laurent, who found that fructose, maltose, mannitol, dulcitol, and glycerol could also contribute directly to the nutrition of leaves.

Bokorny, working with *Spirogyra* immersed in dilute solutions, found that starch production in the chlorophyll bodies could be induced by a large number of organic substances, including, amongst many others, asparagin, citric, tartaric, and lactic acids, leucine, tyrosine, and peptone.[1]

Very much more to the point are the experiments of Acton, made in 1889, and the still more recent work of J. Laurent and of Mazé.

In his experiments on terrestrial plants, Acton, after depleting them of starch, immersed the cut branches or roots, as the case might be, in culture fluids containing certain organic substances, and took precautions to prevent any normal assimilation from taking place by depriving the air around the plant of any trace of carbon dioxide. He was not able to show the direct nutritive influence of so large a range of substances as Bokorny had done for *Spirogyra*, but his results leave no room for doubt that several of the carbohydrates, and even glycerine, can be absorbed by the roots, and can contribute to the nutrition of the green parts. Acton tried, amongst other substances, an "extract of natural humus," which was an aqueous solution of the extractives of a light soil which are soluble in dilute alcohol. This extract was found to be effective in producing a small quantity of starch in the leaves, and it evidently contained some substance or substances directly assimilable by the plant.

Apparently without knowing anything of this work of Acton, J. Laurent has recently made a series of experiments on the culture of the maize plant in mineral solutions containing saccharose, glucose, or invert-sugar, and in this way has not only obtained, as Acton had done before him, evidence of the active formation of starch in the leaves, but has also found a very notable increase in the dry weight of the plant. Although assimilation of the carbohydrate may under these circumstances go on in darkness, Laurent found that the process was much enhanced when light had access to the plant. Mazé, within the last few months, has obtained even more pronounced effects of this kind.

When all these new facts are taken into consideration, I think they justify what I have already said, that we ought to demand more direct evidence than is at present available before we accept the view that the majority of chlorophyllous plants take in *the whole* of their carbon from the atmosphere. In the cycle of change which the organic matter of the soil is constantly undergoing under the influence of micro-organisms, it seems by no means improbable that intermediate substances may be formed which in some measure directly contribute to the nutrition of the higher plants, and we must also by no means lose sight of the possible effect, in the same direction, of the symbiotic union of certain fungi with the root extremities of many plants, the Mycorhizæ, whose functions are still so imperfectly understood. Then, again, we must remember that we have another possible extra-atmospheric source of carbon dioxide in the transpiration water of the plant, which is derived from a soil whose gases may contain 5 per cent. or more of carbon dioxide. From the amount of water transpired in a given time, and an application of the law of partial pressures, it may be readily shown that the supply of carbon dioxide to the aërial organs of a plant from this source is by no means negligible.

Before these problems can be attacked for a particular plant with any hope of success, it is clear that we must have some means of establishing an accurate debtor and creditor account as between the plant and the surrounding atmosphere, and this account must extend over a sufficiently long period, and allow of an accurate balance being struck with the amount of carbon found in the plant at the end of the experiment.

Up to within a few years ago we had no means of even approximately determining the actual rate at which the assimilatory process goes on in a plant other than that afforded by its increase in weight in a given time. Such experiments, necessarily extending over weeks or months, can, at the best, only give us certain average results, and consequently afford no measure of the activity of assimilation under fixed conditions of insolation. In the year 1884, Sachs, who had for some time been at work on the formation of starch in leaves under the action of sunlight, found that the accumulation of freshly assimilated material in a leaf may, under favourable conditions, go on so rapidly as to give rise to a very appreciable increase of weight in the leaf lamina within the short space of a few hours. By observing at

[1] By far the most interesting and important result of Bokorny is the proof he gives that formaldehyde is directly assimilable by *Spirogyra*. His early attempts to show this had been rendered abortive by the highly poisonous nature of this substance. The difficulty was surmounted by using a dilute solution of sodium oxymethylsulphonate, which on warming with water splits up into formaldehyde and acid sodium sulphite. To prevent the unfavourable action of the acid sodium sulphite, dipotassium or disodium phosphate was added to the plant cultures. In such a solution, with rigid exclusion of carbon dioxide, *Spirogyra majuscula* forms starch in its chlorophyll bodies, but the access of light appears to be necessary.

The importance of this experiment is very great in connection with Baeyer's well-known hypothesis that the first act of assimilation is the reduction of carbon dioxide and water to the state of formaldehyde.

different times of the day the varying dry weight of equal areas of large leaves, Sachs obtained an approximate measure of the rate of the assimilatory process which he could express in terms of actual number of grams of substance assimilated by a unit area of leaf in unit of time. In this manner he was able to show, for instance, that a sunflower leaf, whilst still attached to the plant, increases in weight when exposed to bright sunshine at the hourly rate of about one gram per square metre of leaf area. In the case of similar leaves detached from the plant, and of course under conditions in which the products of assimilation were entirely accumulated in the leaf, he found an increase in weight of rather more than $1\frac{1}{2}$ grams per square metre per hour.

I was able to confirm this work of Sachs in the course of an investigation on the Chemistry of Leaves which I made with Dr. G. H. Morris in 1892–93, and there can be no doubt that the variations in the weight of leaves can be used as a fair index of the activity of a leaf in assimilating, but it is not a method which admits of much refinement of accuracy, owing, amongst other things, to the want of perfect symmetry in the leaves as regards thickness and density of the laminæ and to the possible migration of the assimilated material into the larger ribs, which of course cannot be included in the weighings.

It is evident that a far better plan of measuring the rate of assimilation under varying conditions would be the estimation of the actual amount of carbon dioxide entering a given area of the leaf in a certain time, and it was to the perfection of a method of this kind that Mr. Escombe and I first turned our attention.

In all previous attempts to measure the rate of ingress of carbon dioxide, such as those of Corenwinder, and more recently still of Mr. F. F. Blackman, it has been necessary to use air containing comparatively large quantities of carbon dioxide, amounting to 4 per cent. and upwards. Interesting and useful as such experiments undoubtedly are from the point of view from which they were undertaken, we must not lose sight of the fact that such conditions are highly artificial, and very far removed from those under which a plant finds itself in the natural state, where its leaves are bathed with air containing, not 4 or 5 per cent., but only ·03 per cent. of carbon dioxide. I shall have occasion later on to show how remarkably the rate of intake of carbon dioxide into a plant is influenced by extremely small variations in the tension of that gas, and that on this account no deduction can be drawn as to the rate of assimilation under natural conditions from any experiments in which the air contains even so small an amount of carbon dioxide as 1 per cent.

Before proceeding further in this direction, however, it will be well to consider the amount of carbon dioxide which must enter a leaf in a given time in order to produce an influence on its weight comparable with that indicated by the Sachs method of weighing definite areas For this purpose I will consider a leaf with which we have made many experiments—that of *Catalpa bignonioides*. It is a very symmetrical leaf and a good assimilator, and since the intake of carbon dioxide takes place only on the under side, the question to which I wish to draw your attention can be stated in a simple manner. When such a leaf is subjected to a modified form of the half-leaf weighing method of Sachs, into the details of which I cannot here enter, it may, under favourable conditions, show an increase in dry weight equal to about one gram per square metre per hour. Since this increase in weight is due almost entirely to the formation of carbohydrates, we can calculate with a close approximation to accuracy the corresponding amount of carbon dioxide. This will of course depend, within certain narrow limits, on the nature of the carbohydrate formed. The formation of a gram of starch requires 1·628 grams of carbon dioxide, whilst an equal amount of a $C_6H_{12}O_6$ or a $C_{12}H_{22}O_{11}$ sugar require 1·466 and 1·543 grams respectively. From the knowledge we possess of the nature of the carbohydrates of the leaf, we are quite sure that the mean of these values, that is 1·545 grams, must be very near the truth. This amount corresponds to 784 c.c. of carbon dioxide at normal temperature and pressure, which must represent the volume abstracted by the square metre of leaf surface in one hour from air containing only three parts of carbon dioxide in 10,000, supposing the method of leaf weighing to give correct results. We shall see later on that this intake can be verified by direct estimations; it is equivalent to the total amount of carbon dioxide in a column of air of a cross section equal to that of the leaf, and of a height of 26 decimetres.

The extraordinary power which an assimilating leaf possesses of abstracting carbon dioxide from the air is best shown by comparing it with an equal area of a freely exposed solution of caustic alkali. We have made a very large number of experiments on the rate at which atmospheric carbon dioxide can be taken up by a solution of caustic soda under varying conditions, and have been surprised to find how constant the absorption is. In a moderately still air a square metre of surface of such a freely exposed solution will absorb about 1200 c.c. of carbon dioxide per hour, and this can only be increased to about 1500 c.c. even if the dish is exposed to the full influence of a strong wind out in the open. When the surface of the liquid is constantly renewed during the experiment by means of a mechanical stirrer, the rate of absorption is not sensibly affected, providing the agitation does not appreciably increase the surface area, and considerable variations in the strength of the alkaline solution are also without any effect. On the other hand, slight variations in the tension of the carbon dioxide of the air have a marked influence on the rate of absorption, and in order to study this point we have constructed an apparatus which allows us to pass over an absorptive surface of liquid a current of air in a stratum of known thickness, and with a known average velocity.

By introducing definite amounts of carbon dioxide into this stream of air we have been able to determine the influence of its tension on the rate of absorption. At present we have only employed air containing amounts varying from 0·8 to 13 parts per 10,000, that is to say, from about one-quarter to a little more than four times the amount contained in normal air. Within these limits, and probably beyond them, the rate of absorption by the alkaline surface is strictly proportional to the tension of the carbon dioxide in the air current. I shall have occasion to show later on that the same rule holds good with regard to an assimilating leaf, and that in this case also, within certain limits, the intake of the gas is proportional to its tension.

The fact which I wish more particularly to bring out in these comparisons is that a leaf surface which is assimilating at the rate of one gram of carbohydrate per square metre per hour is absorbing atmospheric carbon dioxide *more than half as fast as the same surface would do if wetted with a constantly renewed film of a strong solution of caustic alkali.*

From what I have just said about the influence of tension on the absorption of carbon dioxide by an assimilating leaf, it is clear that any attempts to determine by direct means the natural intake of that gas during assimilation must be made with *ordinary* air, and that such experiments can only be carried out on a comparatively large scale. We had in the first instance to devise an apparatus which would rapidly and completely absorb the whole of the carbon dioxide from a stream of air passing through it at the rate of from 100 to 200 litres per hour, and at the same time admit of an extremely accurate determination of the absorbed carbon dioxide.

The absorbing apparatus which we finally adopted is a modification of one used by Reiset in his estimations of the carbon dioxide of the atmosphere. It consists essentially of a glass tube 50 cm. long, fixed vertically in a wide-mouthed glass vessel furnished with a second aperture and tubulure. The height of the vertical tube is invariable, but its width is regulated according to the amount of air required to be drawn through the apparatus in a given time. The bottom of this tube is closed with a platinum or silver plate pierced with a large number of very small holes, and two other similar perforated plates are inserted in the tube at certain intervals. The upper part of the tube is put in connection with an aspirating water-pump, and the absorbing liquid is placed in the lower glass vessel, whose second tubulure is connected with the supply of air in which the carbon dioxide has to be determined. When the aspirator is started the liquid is first drawn up into the vertical tube, and the air then follows through the perforated plates which act as "scrubbers." Reiset, in his work, used baryta water as the absorbent, an aliquot part of which was titrated before and after the experiment, the changes in the volume of the liquid being corrected for by certain devices which I need not describe.

The efficiency of the apparatus as a complete absorber of atmospheric carbon dioxide leaves nothing to be desired, but in dealing with large quantities of baryta solution, amounting to 400 c.c. or more, the errors due to inaccurate titrations, or to over or under estimation of the volume changes, are all thrown on the final result, of which they may form a considerable part. We have consequently altogether discarded the use of baryta as an absorbent in favour of caustic soda. The carbonate is esti-

mated by a double titration process, suggested a few years ago by Hart, and we have succeeded in so far improving this method that there is no difficulty in determining in 100 c.c. of the alkaline solution an amount of carbonate corresponding to $\frac{1}{10}$ c.c. of carbon dioxide.

There is practically no limit to the amount of air which can be passed through an absorbing apparatus such as I have described, and one of very moderate dimensions will allow from 100 to 150 litres per hour to pass with perfect safety. Larger amounts can be dealt with either by increasing the size of the apparatus or by using several smaller ones arranged in parallel.

With proper precautions, determinations can certainly be made to within ·02 part of carbon dioxide in 10,000 of air, so that with an apparatus of this kind it is possible to estimate the intake of carbon dioxide into a leaf or plant from ordinary atmospheric air, and to keep a sufficiently rapid stream of air passing over the leaf to maintain the tension of the carbon dioxide only slightly below the normal amount.

The air is measured by carefully standardised meters, reading to about 20 c.c.; and since the amounts of air aspirated vary from 100 to 900 litres or more, there are practically no errors of measurement. The tension at which the air passes through the absorption apparatus is measured by a manometer, and all the volumes are reduced to standard temperature and pressure.

All such experiments of course necessitate, not only a determination of the carbon dioxide in the air which has passed over the leaf or plant, but also a simultaneous determination of the carbon dioxide in the ordinary air used. The accumulation of these air determinations clearly shows that the ordinary statements of our text-books as to the amount of carbon dioxide and its limits of variation are altogether misleading.

In our experiments the air was in all cases taken from a height of four feet six inches from the ground, the amounts aspirated varying from 100 to 500 litres.

In the month of July 1898, the minimum amount of carbon dioxide found was 2·71 parts per 10,000 of air, and the maximum 2·86. During the winter months, when the ground was almost bare of vegetation, it rose to from 3·00 to 3·23 parts per 10,000; and on one foggy day, March 16, 1899, after a whole week of similar weather, we found the very exceptional amount of 3·62. As a rule, we may take it that the amount of carbon dioxide in the atmosphere during the period of greatest plant growth rarely falls short of 2·7 parts per 10,000, and rarely exceeds 3·0 parts, with an average of about 2·85. These numbers come very close to the determinations of Reiset, and of Müntz and Aubin, and agree also fairly well with the Montsouris determinations.

If instead of taking the air from a height of three or four feet from the ground, we examine the stratum only one or two centimetres above the surface of a soil free from vegetation, we find, as might be expected, a very large increase in the amount of carbon dioxide, which may exceed, under these circumstances, 12 or 13 parts per 10,000 of air. Such a soil, in fact, gives off by diffusion into the surrounding air an amount of carbon dioxide which is comparable to that evolved by a respiring leaf, that is to say, about 50 c.c. per square metre per hour. This is probably a factor which has to be taken into account in considering the assimilative power of vegetation of very low growing habit, but in all other cases we may assume with safety that aërial plants have to take in their carbon dioxide from air in which its tension does not exceed $\frac{3}{10000}$ of an atmosphere.

The actual intake of carbon dioxide is determined by enclosing the entire leaf in specially constructed air-tight, glazed cases, through which a sufficiently rapid air stream is passed. These cases are so arranged tbat the leaf can be enclosed whilst still attached to a plant which is growing out in the open under perfectly natural conditions, and some of them are sufficiently large to take the entire leaf of a sunflower.

The carbon dioxide content of the air is determined both before and after its passage through the apparatus, and since the amount of air passed is known we have all the data requisite for determining the actual amount retained by the leaf.

An experiment generally lasts from five to six hours, and the carbon dioxide fixed in this time may amount to 150 c.c. or more, the actual error of determination being very small indeed.

For purposes of comparison the volumes are reduced to the actual number of cubic centimetres of the gas absorbed by a square metre of leaf in one hour, which of course necessitates an exact determination of the area of the leaf. This is most conveniently effected by printing the leaf on sensitised paper, and tracing round its outline with a planimeter set to read off square centimetres—a far more accurate and expeditious plan than that of cutting out a fac simile of the leaf from paper of a known weight per unit of area.

If it is desired to estimate the assimilative power of a leaf in an atmosphere artificially enriched with carbon dioxide, the air stream before entering the leaf case is passed through a small tower containing fragments of marble, over which there drops a very slow stream of dilute acid, whose rate of flow is so proportioned to the air stream as to give about the desired enrichment with carbon dioxide. The stream of air is then divided, one part going on directly to the leaf case, whilst the other passes through a separate absorption apparatus and meter for the accurate determination of its carbon dioxide content.

In order to show the kind of results obtained in this manner, I will give one or two examples.

A leaf of the sunflower, having an area of 617·5 sq. cm., was enclosed in its case whilst still attached to the plant, and was exposed to the strong diffuse light of a clouded sky for five and a half hours, air being passed over it at the rate of nearly 150 litres per hour. The content of the air in carbon dioxide as it entered the apparatus was 2·80 parts per 10,000, and this was reduced to 1·74 parts per 10,000 during its passage over the leaf. This corresponds to a total absorption of 139·95 c.c. of carbon dioxide, or to an intake of 412 c.c. per square metre per hour. If we assume that the average composition of the carbohydrates formed is that of a $C_6H_{12}O_6$ sugar, the above amount of carbon dioxide corresponds to the formation of 0·55 gram of carbohydrate per square metre per hour. But we must bear in mind that the average tension of the carbon dioxide in the leaf case was only equal to 1·93 parts per 10,000—that is, only about seven-tenths of its tension in the normal air. A correction has therefore to be made if we wish to know how much the leaf would have taken in, under similar conditions of insolation, if it had been bathed with a current of air of sufficient rapidity to practically keep the amount of carbon dioxide constant at its normal amount of 2·8 per 10,000. We shall see later on that, well within the limits of this experiment, the intake is proportional to the tension, so that applying this correction we may conclude that under identical conditions of insolation and temperature this leaf would have taken in an amount of carbon dioxide from the free air at a rate sufficient to produce 0·8 gram of carbohydrate per square metre per hour. This is almost exactly equal to the assimilation rate of the sunflower which I deduced in 1892 from the indirect process of weighing equal areas of the leaf lamina before and after insolation, and it also agrees fairly well with some of Sachs' original experiments of a similar nature.

In another experiment made with the leaf of *Catalpa bignonioides* in full sunlight, the amount of carbon dioxide in the air passing over the leaf fell from 2·80 to 1·79 parts per 10,000, the total hourly intake for the square metre being 344·8 c.c. When this is corrected for tension, it corresponds to an assimilation in free air of 0·55 gram of carbohydrate per square metre per hour.

An increase in the intensity of the daylight, as might be expected, influences to some extent the rate of intake of atmospheric carbon dioxide; but providing the illumination has reached a certain minimum amount, a further increase in the radiant energy incident on the leaf does not result in anything like a proportional amount of assimilation. We have found, for instance, that the rate of assimilation of a sunflower leaf, exposed to the clear northern sky on a warm summer's day, was about one-half of what it was when the leaf was turned round so as to receive the direct rays of the sun almost normal to its surface. Now in this latter case the actual radiant energy received by the leaf was at least twelve times greater than was received from the northern sky, but the assimilation was only doubled.

These differences in the effect of great variation of illumination become stil less marked when we use air which has been artificially enriched with carbon dioxide. In one instance of this kind, for example, we found the assimilation in the full diffuse light of the northern sky to be 87 per cent. of what it was in direct sunshine.

This brings me to another interesting point on which I have

already touched slightly—the enormous influence which slight changes in the carbon dioxide content of the air exert on the rate of its ingress into the assimilating leaf.

With a constant illumination, either in direct sunlight or diffuse light, the assimilatory process responds to the least variation in the carbon dioxide, and within certain limits, not yet clearly defined, the intake of that gas into the leaf follows the same rule as the one which holds good with regard to the absorption of carbon dioxide by a freely exposed surface of a solution of caustic alkali; that is to say, from air containing small but variable quantities of carbon dioxide *the intake is directly proportional to the tension of that gas.*

A single experiment will be sufficient to illustrate this.

A large sunflower leaf, still attached to the plant and exposed to a clear northern sky, gave an assimilation rate equal to 0·331 gram of carbohydrate per square metre per hour, when air was passed containing an average amount of 2·22 parts of carbon dioxide per 10,000. When the experiment was repeated under similar conditions of illumination, but with air containing 14·82 parts of $CO_2$ per 10,000, the intake corresponded to an hourly formation of 2·409 grams of carbohydrate per square metre. The ratio of the tensions of the carbon dioxide in the two experiments is 1 to 6·7, and the assimilatory ratio is 1 to 7·2, so that the increased assimilation is practically proportional to the increase in tension of the carbon dioxide.

Since an increase of carbon dioxide in the atmosphere surrounding a leaf is followed by increased assimilation even in diffuse daylight, it is clear that, under all ordinary conditions of illumination, the rays of the right degree of refrangibility for producing decomposition of carbon dioxide are largely in excess of the power of the leaf to utilise them. Under natural conditions this excess of radiant energy of the right wave-length must, from the point of view of the assimilatory process, be wasted, owing to the limitation imposed by the high degree of dilution of atmospheric carbon dioxide. But although the actual manufacture of new material within the leaf lamina is so largely influenced by small variations in the carbon dioxide of the air, we are not justified in concluding that the plant *as a whole* will necessarily respond to such changes in atmospheric environment, since the complex physiological changes involved in metabolism and growth may have become so intimately correlated that the perfect working of the mechanism of the entire plant may now only be possible in an atmosphere containing about three parts of carbon dioxide in 10,000.

We have commenced a series of experiments which will, I hope, throw considerable light on this point, but the work is not at present in a sufficiently advanced state for me to make more than a passing allusion to it.

The penetration of the highly diluted carbon dioxide of the atmosphere into the interior air-spaces of the leaf on its way to the active centres of assimilation must, in the first instance, be a purely physical process, and no explanation of this can be accepted which does not conform to the physical properties of the gases involved.

Since there is no mechanism in the leaf capable of producing an ebb and flow of gases within the air spaces of the mesophyll in any way comparable with the movements of the tidal air in the lungs of animals; and since also the arrangement of the stomatic openings is such as to effect a rapid equalisation of pressure within and without the leaf, we must search for the cause of the gaseous exchange, not in any mass movement, but in some form of diffusion. This may take place in the form of *open diffusion* through the minute stomatic apertures, which are in communication both with the outer air and the intercellular spaces, or the gaseous exchange may take place through the cuticle and epidermis by a process of *gaseous osmosis*, similar to that which Graham investigated in connection with certain colloid septa.

For many years there has been much controversy as to which form of gaseous diffusion is the more active in producing the natural interchanges of gases in the leaf. The present occasion is not one in which full justice can be done to the large amount of experimental work which has from time to time been carried out in this direction. Up to comparatively recently the theory of cuticular osmosis has been the one which has been more commonly accepted, free diffusion through the open stomata being considered quite subsidiary. In 1895, however, Mr. F. F. Blackman brought forward two remarkable papers which opened up an entirely new aspect of the subject. After showing the fallacy underlying certain experiments of Boussingault, which had been generally supposed to prove the osmotic theory of exchange, Mr. Blackman gave the results of his own experiments with a new and beautifully constructed apparatus, which enabled him to measure very minute quantities of carbon dioxide given off from small areas of the upper and under sides of a respiring leaf, and also to determine the relative intake of carbon dioxide by the two surfaces during assimilation in air artificially charged with that gas. The conclusions drawn are that respiratory egress, and assimilatory ingress of carbon dioxide, do not occur in the upper side of a leaf if this is devoid of stomatic openings, and that when these openings exist on both the upper and under sides the gaseous exchanges of both physiological processes are directly proportional to the number of stomata on equal areas, hence in all probability the exchanges take place only through the stomata.[1]

These observations of Mr. Blackman are of such far-reaching importance, and lead, as we shall see presently, to such remarkable conclusions with regard to the rate of diffusion of atmospheric carbon dioxide, that we felt constrained to inquire into the matter further, and for this purpose we employed a modified form of the apparatus which we have used throughout our work on assimilation. This was so arranged that a current of ordinary air could be passed, just as in Mr. Blackman's experiments, over the upper and lower surface of a leaf separately, the increase or decrease in the carbon dioxide content of the air being determined by absorption and titration in the manner I have already alluded to.

In this way we were able to employ comparatively large leaf areas, and to continue an experiment for several hours, so that we had relatively large amounts of carbon dioxide to deal with, and the ratios of gaseous exchange of the two sides of the leaf could consequently be determined with considerable accuracy.

Our results, on the whole, are decidedly confirmatory of Mr. Blackman's observations. The side of a leaf which is devoid of stomatic openings certainly neither allows any carbon dioxide to escape during respiration, nor does it permit the ingress of that gas when the conditions are favourable for assimilation. On the other hand, when stomata exists on both the upper and under sides of a leaf, gaseous exchanges take place through both surfaces, and, as a rule, in some sort of rough proportion to the distribution of the openings. There is, however, under strong illumination, a greater intake of carbon dioxide through the upper surface than would be expected from a mere consideration of the ratio of distribution of the stomata.[2] Nevertheless, the general connection between gaseous exchange and distribution of stomata is so well brought out that we must regard it as highly probable that these minute openings are the true paths by which the carbon dioxide enters and leaves the leaf.

We must now look at certain physical consequences which proceed from this assumption, and see how far they can be justified by the known or ascertainable properties of carbon dioxide at very low tensions.

The leaf of *Catalpa bignonioides* is hypostomatic, and therefore takes in carbon dioxide only by its lower surface. Under

[1] There is one important fact to be borne in mind when considering how far these observations exclude the possibility of cuticular osmosis. In the many leaves we have examined, Mr. Escombe and I have found that the occurrence of stomata on the upper surface of the leaf is always correlated with a much less dense palisade parenchyma. The cuticle and epidermis under these conditions are in a much more favourable state to allow carbon dioxide to pass into the leaf by osmosis than when the closely-packed palisade-cells abut against the epidermis, as they do when this is imperforate.

[2] Granted that the stomata constitute the paths of gaseous exchange, it is clear that the amount of diffusion through them, other things being equal, must depend very largely on the extent to which they are opened. The delicate self-regulating apparatus which governs the size of the openings is so readily influenced, amongst other things, by differences of illumination, that *a priori* we should not expect the stomata on the upper surface of an insolated leaf to be in the same condition as those of the more shaded lower surface. This may very well account for the stomatic ratio of the two sides not being in closer correspondence with the assimilatory ratios, as found in most of our experiments carried out in bright sunlight. In light of lesser intensity there is always a closer correspondence of the two ratios.

There is also another possible explanation of the fact. Since we have good reason to believe that the principal part of the assimilatory work is carried on by the palisade parenchyma, which occurs in the upper side of the leaf, the tension of the carbon dioxide in the air spaces of that part of the mesophyll is probably less than it is in the spongy parenchyma. There will, therefore, be a higher "diffusion gradient" between the carbon dioxide of the outer and inner air in the former case than in the latter, and this would certainly tend to a more rapid diffusion through the openings in the upper side of the leaf.

favourable conditions it is quite possible, during assimilation, to obtain an intake of atmospheric carbon dioxide into this leaf at the rate of 700 c.c. per square metre per hour (measured at 0° and 760 mm.), corresponding to an average linear velocity of the carbon dioxide molecules of 3·8 *centimetres per minute*, supposing the intake to be distributed evenly over the whole of the lower leaf surface. This velocity is almost exactly one-half of that at which carbon dioxide will enter a freely exposed surface of a solution of caustic alkali. But if the intake of the gas is confined to the stomatic openings of the leaf, its velocity of ingress must be very much greater than this.

We have carefully determined the number of stomata occurring on a given area of this particular leaf, and also the dimensions of the openings, and find that the total area of the openings, supposing them to be dilated to the fullest possible extent, amounts to just under *one per cent.* of the leaf surface. It follows from this that the average velocity of the atmospheric carbon dioxide in passing through these openings must be 380 *centimetres per minute*, that is to say, just *fifty* times greater than into a freely exposed absorbent surface of alkali. In other words, supposing every one of the stomatic openings of this leaf could be filled up with a solution of caustic alkali, the absorbent power of the leaf as a whole would only be $\frac{1}{50}$ of what it actually is when assimilating.

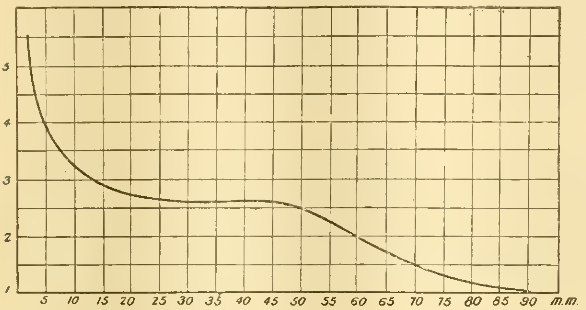


FIG. 1.

These are some of the consequences which flow from an acceptance of the hypothesis of stomatic exchange, and it appeared to be impossible to accept that hypothesis unreservedly without some collateral evidence that these comparatively high velocities of diffusion are physically possible when dealing with such low gradients of tension as must necessarily exist when the highest amount of carbon dioxide does not exceed ·03 per cent.

The well-known general law expressing the rate of the spontaneous intermixture of two gases when there is no intervening septum was, as every one knows, established by Graham, and the more elaborate investigations of Loschmidt many years later served to confirm the general accuracy of this law, and to show that, within very narrow limits, the diffusion constant varies in different gases inversely as the square roots of their densities.

But a mere knowledge of the diffusion constants of air and carbon dioxide does not, as far as I can see, materially assist us in the particular case we have under consideration. In order to gain some idea of what is actually possible in the way of stomatic diffusion in an assimilating leaf, we must know something of the *actual rate* at which atmospheric carbon dioxide can be made to pass into a small chamber containing air at the outside tension, but in which the carbon dioxide is kept down almost to the vanishing point by some rapid process of absorption; and we must also determine the influence of varying the size of the aperture through which the diffusion takes place.

Our attempts to answer these questions experimentally have led us into a long investigation, which promises to be of wider interest than we had first imagined. I only propose to give on this occasion a general account of the results so far as they affect the physical question of the intake of carbon dioxide into the plant.

When a shallow vessel containing a solution of caustic alkali is completely covered, the air above the liquid is very speedily deprived of the whole of its carbon dioxide. If we now imagine a hole to be made in the cover of the vessel, carbon dioxide will enter the air space by free diffusion, and its amount can be very accurately determined by subsequent titration in the manner I have previously referred to. The time occupied by the experiment and the dimensions of the aperture being known, we can express the results in actual amounts of carbon dioxide passing through unit area of aperture in unit of time; or, since the tension of that gas in the outer air is known, we can express the average rate of the carbon dioxide molecules across the aperture in terms of actual measurement, say centimetres per minute.

We have made a very large number of experiments of this kind, using, in the first instance, dishes of about 9 cm. in diameter, and varying the size of the holes in the cover, the air space over the absorbent liquid being always the same.

The accompanying curve, Fig. 1, illustrates the effect which a gradually decreasing orifice has on the rate of diffusion of atmospheric carbon dioxide under these conditions. The diameters of the orifice in millimetres are given on the abscissa line, and the rates of diffusion through equal areas of the apertures are taken as ordinates, the rate of absorption in the open dish under similar conditions being taken as unity.

It will be seen that in the first instance a gradual reduction of the diameter of the opening is accompanied by a very regular increase in the rate of passage of the carbon dioxide until a diameter of about 50 mm. is reached; that is to say, up to a point at which about two-thirds of the area of the dish is covered. A further progressive diminution in the size of the aperture makes comparatively little difference in the diffusion rate until we reach about 20 mm., beyond which the curve again begins to rise, increasing rapidly in steepness as the apertures become smaller.

The experiments with open dishes are too crude for a study of the influence of very small apertures, so for this part of our work we constructed a special form of apparatus which has enabled us to determine the relative rates of diffusion through orifices in thin metal plates ranging down to 1 mm. in diameter.

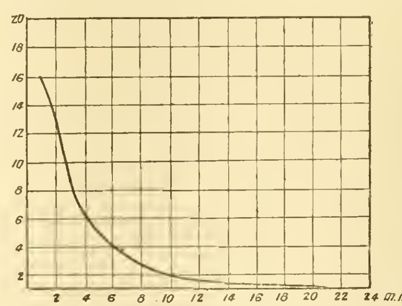


FIG. 2.

I have plotted the results of such a series of experiments (see Fig. 2), showing the relative rates of diffusion of atmospheric carbon dioxide through equal areas of apertures between 20 mm. and 1 mm. in diameter, under constant conditions, and it will be noticed how very steep the curve becomes after diameters of 5 or 6 mm. are reached.

The speed at which the diffusion of atmospheric carbon dioxide takes place through unit area of an orifice of 1 mm. in diameter is just sixteen times as fast as it is through unit area of an aperture of 20 mm.; and since we know that the rate of passage in the latter case is two and a half times greater than

the absorption rate of an equal area of a freely exposed surface of a solution of caustic alkali, we arrive at the conclusion that, under the particular conditions of our experiment, the diffusion rate through an aperture of 1 mm. is *forty times* greater than the rate of absorption of a free alkaline surface of equal area.

This corresponds to an actual average rate of passage of the molecules of the atmospheric carbon dioxide of about 266 centimetres per minute.

Now, we have already seen, in the case of a Catalpa leaf, that if the gaseous exchange during assimilation goes on only through the stomatic openings, we require a minimum velocity of something like 380 centimetres per minute, a velocity which we are sensibly approaching in our experiments with apertures of about 1 mm. in diameter. But the effective area of a stomatic opening of the Catalpa leaf is equal to that of a circle with a diameter of less than 1/100 mm., and since our experiments indicate a very rapid increase in the velocity of diffusion as the aperture is diminished, it is clear that no difficulty, as regards the physics of the question, can be raised against the idea that atmospheric carbon dioxide reaches the active centres of assimilation by a process of free diffusion through the leaf stomata.

One of the most interesting problems connected with plant assimilation relates to the efficiency of a green leaf as an absorber and transformer of the radiant energy incident upon it.

It is already well known that the actual amount of energy stored up in the products of assimilation bears a very small proportion to the total amount reaching the leaf: in other words, the leaf, regarded from a thermo-dynamic point of view, is a machine with a very low "economic coefficient." We require, however, to know much more than this, and to ascertain, amongst other things, how the efficiency of the machine varies under different conditions of insolation, and in atmospheres containing varying amounts of carbon dioxide.

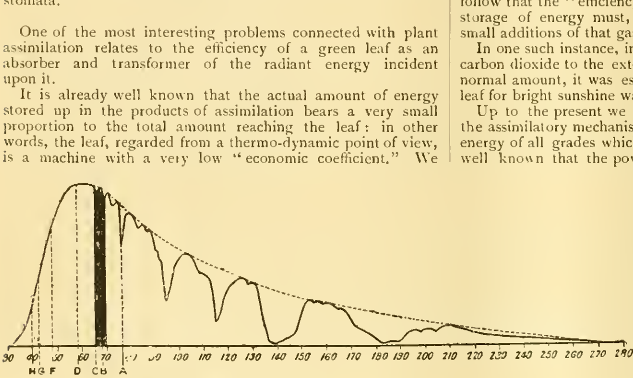



FIG. 3.

The measure of the two principal forms of work done within the leaf, the vaporisation of the transpiration water on the one hand, and the reduction of carbon dioxide and water to the form of carbohydrates on the other, can be ascertained by modifying our experiments in such a manner as to allow the transpiration water to be determined, as well as the intake of carbon dioxide.

For the actual measurement of the total energy incident on the leaf under various conditions we are now using one of Prof. Callendar's recording radiometers of specially delicate construction, which will be ultimately calibrated in calories. This instrument gives promise of excellent results, but up to the present time the work we have done with it is not sufficiently advanced for me to describe. We may, however, obtain a very fair idea of the variation in the efficiency of a leaf from one or two examples in which the amount of incident energy was deduced from other considerations.

In the case of a sunflower leaf exposed to the strong sunlight of a brilliant day in August, the average amount of radiant energy falling on the leaf during the five hours occupied by the experiment was estimated at 600,000 calories per square metre per hour. The averege hourly transpiration of water during that time was at the rate of 275 c c. per square metre, and the assimilated carbohydrate, estimated by the intake of carbon dioxide, was at the rate of 0·8 gram per square metre per hour.

The vaporisation of 275 c.c. of water must have required the expenditure of 166,800 calories, and the endothermic production of 0·8 gram of carbohydrate (taking the heat of combustion at 4000 gram calories) corresponds to the absorption of 3200 calories. Thus, as the final result under these particular conditions of experiment, we find that the leaf has absorbed and converted into internal work about 28 per cent. of the total radiant energy incident on it, 27·5 per cent. being used up in the vaporisation of water, and only *one-half per cent.* in the actual work of assimilation.

In strong diffuse light, such as that from a northern sky on a clear summer's day, the leaf has a higher "economic coefficient," using that term in relation to the permanent storage of energy in the assimilatory products. In one instance of this kind in which the total energy received by the leaf was approximately 60,000 calories per square metre per hour, it was found that 96 c.c. of water were evaporated and 0·41 gram of carbohydrate was formed for the same area and time. This indicates an absorption and utilisation by the leaf of something like 95 per cent. of the incident energy, of which 2·7 per cent has been made use of for actual work of assimilation as against 0·5 per cent. in brilliant sunshine.[1]

From what I have said previously about the effect of increased tension of carbon dioxide on the rate of assimilation, it must follow that the "efficiency" of a leaf as regards the permanent storage of energy must, *caeteris paribus*, be increased when small additions of that gas are made to the surrounding air.

In one such instance, in which the air had been enriched with carbon dioxide to the extent of about five-and-a-half times the normal amount, it was estimated that the "efficiency" of the leaf for bright sunshine was raised from 0·5 to 2·0 per cent.

Up to the present we have been regarding the efficiency of the assimilatory mechanism of a plant in reference to the *total* energy of all grades which falls upon the leaf. It is, of course, well known that the power of decomposing carbon dioxide is limited to rays of a certain refrangibility, and the researches of Timiriazeff, Engelmann and others leave little room to doubt that the rays of the spectrum which are instrumental in producing the reaction in the chloroplastids have a distinct relation to the absorption bands of the leaf-chlorophyll. By far the greater amount of the assimilatory work, probably more than 90 per cent. of it, is effected by the rays which correspond to the principal absorption band in the red, lying between wave-lengths 6500 and 6975.[2] If, therefore, we express the distribution of energy in a normal solar spectrum in the form of a curve, we have the means of approximately determining the *maximum theoretical efficiency* of a green leaf, that is to say, the maximum amount of assimilatory work which could be produced, supposing the conditions so favourable as to admit of the whole of the energy corresponding to this absorption band being stored up within the leaf.

It is not without interest to get an approximate idea of this theoretical maximum.

For this purpose I have here reproduced a curve given by Prof. S. P. Langley representing the distribution of energy at the sea-level in the normal spectrum of a vertical sun shining in

[1] The principal factor which determines the amount of transpiration in a plant must be the amount of radiation falling on it. It is essential that the water-bearing mechanism should be able to keep up a good supply of water to the leaf lamina in order to prevent the temperature rising to a dangerously high point. This "safety valve" function of the transpiration current is not always sufficiently borne in mind, and we are too apt to think that the plant requires these enormous amounts of water in order to supply itself with the requisite mineral salts. The absolute necessity for the supply as a dissipator of energy will become evident by taking one or two facts into consideration. A square metre of the lamina of the leaf of a sunflower weighs about 250 grams, and its specific heat is about 0·9. We have seen that the hourly transpiration in bright sunshine may be as much as 275 c.c. per square metre, requiring the expenditure of 162,800 calories, and it therefore follows that, if the loss of water were stopped, the temperature of the leaf would rise at the rate of more than 12° C. *per minute*. In making our experiments in glazed cases it has sometimes been very interesting to watch the result of any accidental stoppage of the water-current in the leaf-stalk, and the almost instantaneous effect this has in destroying the leaf when the insolation is of high intensity.

[2] These limits are those of the band as measured by passing sunlight through the leaf itself. In an alcoholic solution of chlorophyll the band lies between λ 6400 and λ 6850. I must here express my thanks to Mr. Charles A. Schunck for having kindly undertaken to make these measurements for me.

a clear sky. The total amount of incident energy represented by the whole area of the curve is 1·7 calories per square centimetre per minute, or 1,020,000 calories per square metre per hour.

I have drawn a thick black vertical band in the red end of the spectrum corresponding in position and breadth with the principal absorption band of chlorophyll as seen in a green leaf. By integration it may be shown that the area of this part of the curve is about 6·5 per cent. of that of the whole curve, so that this value represents something like the theoretical maximum efficiency of a leaf in bright vertical sunshine, supposing the conditions could be made so favourable as to result in a complete filtering-out and utilisation of the whole of the rays of the right period for producing decomposition of carbon dioxide.

This maximum efficiency expressed in calories per square metre per hour is 66,300, corresponding to the heat of formation of about 16·5 grams of carbohydrate. Under the most favourable conditions we have employed up to the present we have not obtained a larger production than about 3·0 grams of carbohydrate per square metre per hour, or about 18 per cent. of the theoretical maximum; but this was in air containing only 16·4 parts of carbon dioxide per 10,000, which must be very far below the true optimum amount.

The brilliant discoveries of recent years on the constitution and synthesis of the carbohydrates have not brought us sensibly nearer to an explanation of the first processes of the reduction of carbon dioxide in the living plant. The hypothesis of Baeyer still occupies the position it did when it was first put forward nearly thirty years ago, although it has, it is true, received a certain amount of support from the observations of Bokorny, who found that formaldehyde can, under certain conditions, contribute to the building up of carbohydrates in the chloroplasts.

The changes which go on in the living cell are so rapid, and are of such a complex kind, that there seems little or no hope of ascertaining the nature of the first steps in the process unless we can artificially induce them under much simpler conditions.

The analogy which exists between the action of chlorophyll in the living plant and that of a *chromatic sensitiser* in a photographic plate, was, I believe, first pointed out by Captain Abney, and was more fully elaborated by Timiriazeff, who was inclined to regard chlorophyll as the sensitiser *par excellence*, since it absorbs and utilises for the assimilatory process the radiations corresponding approximately to the point of maximum energy in the normal spectrum. The view which Timiriazeff has put forward, that there is a mere physical transference of vibrations of the right period from the absorbing chlorophyll to the reacting carbon dioxide and water, is, I think, far too simple an explanation of the facts. Chromatic sensitisers have been shown to act by reason of their antecedent decomposition and not by direct transference of energy, and the same probably holds good with regard to chlorophyll, which is also decomposed by the rays which it absorbs. We must probably seek for the first and simplest stages of the assimilatory process in the interaction of the reduced constituents of the chlorophyll and the elements of carbon dioxide and water, the combinations so formed being again split up in another direction by access of energy from without.

The failure of all attempts to produce such a reaction under artificial conditions is, I think, to be accounted for by the neglect of one very important factor. We are dealing with a reaction of a highly endothermic nature, which is probably also highly *reversible*, and on this account we cannot expect any sensible accumulation of the products of change unless we employ some means for removing them from the sphere of action as fast as they are formed.

In the plant this removal is provided for by the living elements of the cell, by the chloroplast, assisted no doubt by the whole of the cytoplasm. We have here, in fact, the analogue of the *chemical sensitisers* of a photographic plate, which act as halogen absorbers, and so permit a sensible accumulation of effect on the silver salts.

When we have succeeded in finding some simple chemical means of fixing the initial products of the reduction of carbon dioxide, then, and then only, may we hopefully look forward to reproducing in the laboratory the first stages of the great synthetic process of nature on which the continuance of all life depends.

## *NOTES.*

THE Allahabad *Pioneer Mail* understands that Mr. J. N. Tata, of Bombay, has determined to dissociate his offered endowment for a scientific research institute in India from the proposed family settlement, which was one of the original conditions, as the latter part of the scheme presented insuperable difficulties. With great generosity and public spirit Mr. Tata has declared his intention of making his offer, which amounts, it will be remembered, to some thirty lakhs of property, quite unconditional. He is now preparing, in consultation with the provisional committee, a revised scheme for submission to Government. In preparing it, he and the provisional committee will utilise all the information and advice they have received from all parts of India in response to the circulars issued some months ago, and there is good prospect of a practical plan being evolved.

THE forty-eighth annual meeting of the American Association for the Advancement of Science was held at Columbus, Ohio, on August 19–26, under the presidency of Dr. Edward Orton, of Ohio State University. There were 350 members and associates present, and 273 papers were communicated to the sections. The address of the retiring president, Prof. F. W. Putnam, of Harvard University, was published in last week's NATURE, and portions of the addresses delivered by presidents of the sections will appear at the earliest opportunity. The subjects of these addresses are:—Section of Mathematics and Astronomy, "The Fundamental Principles of Algebra," by Prof. A. Macfarlane; Section of Mechanical Science and Engineering, "Engineering Education as a Preliminary Training for Scientific Research Work," by Prof. Storm Bull; Section of Zoology, "The Importance and the Promise in the Study of the Domestic Animals," by Prof. Gage; Section of Geology and Geography, "The Devonian in Canada," by Mr. J. F. Whiteaves; Section of Physics, "The Field of Experimental Research," by Dr. Elihu Thomson; Section of Chemistry, "Definition of the Element," by Prof. F. P. Venable; Section of Botany, "The Progress and Problems of Plant Physiology," by Prof. Barnes; Section of Anthropology, "Beginnings of the Science of Prehistoric Anthropology," by Prof. Wilson. Prof. C. E. Munroe delivered a popular lecture on "Applications of Modern Electricity." New York was selected as the place of meeting next year, and Prof. R. S. Woodward, Columbia University, was nominated president.

A VERY successful congress of mining engineers was held at Teplitz, in Bohemia, on September 4–8. It was attended by 400 mining engineers from all parts of Austria and by a few representatives of other countries, Great Britain being represented by Mr. H. Bauerman, Mr. Bennett Brough and Mr. D. A. Louis. Mr. Gottfried Hüttemann, of Brüx, was elected president; Mr. J. Gleich, of Klagenfurt, and Prof. Clemens Winkler, of Freiberg, vice-presidents; and Prof. J. von Ehrenwerth, of the Przibram School of Mines, and Mr. M. Heinsius, secretaries. Papers were read by Prof. Clemens Winkler, on the history of combustion with reference to the duration of the world's coal supply; by Prof. Otto Frankl, of Prague, on suggested reforms in mining law; by Mr. H. Löcker, of Brüx, on water-inbursts in the Dux-Ossegg collieries and their influence on the Teplitz hot-springs; and by Mr. A. Bloemendal, of Vienna, on the electric transmission of power in mines. It was decided that the next mining congress should be held in Vienna in four years' time. In connection with the congress, excursions were arranged to the brown coal mines of the Brüx Coal Co. and of the Bruch Coal Co., to the Teplitz rolling mills, to the Aussig chemical works, to Edmundsklamm and other points of geological interest in the Bohemian Switzerland, and to the

Kladno collieries. The importance of the brown coal mines of the Teplitz district is shown by the fact that last year they produced no less than 15,044,563 tons, and afforded employment to 25,212 workmen.

THE reports which the *Times* correspondent at St. Johns has received from the members of the Peary Polar expedition, who have returned in the steamer *Windward*, are disappointing. Grinnell Land was explored to its western extremity last autumn; the north remains to be explored. Next spring, Lieut. Peary will undertake the three years' further prosecution of his quest for the pole. Captain Sverdrup, in the *Fram*, wintered fifty miles south of the *Windward*, in latitude 79°. The work of the expedition has so far been unimportant.

THE Danish Greenland expedition, under Lieut. Amstrup, has returned to Mandal, after a year's absence, and reports that no trace was found of Herr Andrée and his companions. A Reuter telegram states that the Swedish search expedition under Dr. Nathorst, which has just arrived at Malmo, brings a similar report. The expedition explored Kaiser Franz Joseph Fiord, on the east coast of Greenland, and there discovered a whole series of new inlets, the position of which was mapped. An especially interesting ethnographical collection relating to the now extinct Eskimo population was secured in that region.

THE forty-fourth annual exhibition of the Royal Photographic Society, which will be held at the Gallery of the Royal Society of Painters in Water Colours, is now in course of preparation, and will be opened to the public on Monday, September 25, for a period of seven weeks. On Saturday, the 23rd, there will be a private view for members, exhibitors, and their friends, and in the evening there will be a conversazione, when the President, the Earl of Crawford, K.T., will receive the members and the other guests of the Society.

A CONGRESS of the Royal Institute of Public Health will be held at Blackpool on September 21-28.

A COURSE of twelve free lectures on the "Pleistocene Mammalia" will be delivered by Dr. R. H. Traquair, F.R.S., in the Lecture Theatre of the Museum of Practical Geology, Jermyn Street, S.W., on Mondays, Wednesdays and Fridays, at 5 p.m., beginning Monday, October 2, and ending Friday, October 27.

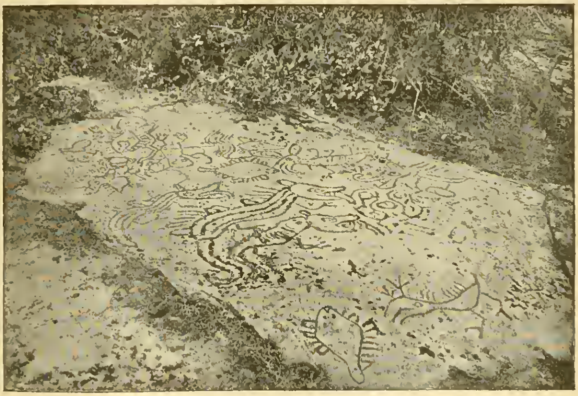
THE committee appointed by the American Chemical Society to consider the means by which the Society could hasten the adoption of uniform systems of graduation, definite limits of accuracy, and standard methods for using all forms of measuring instruments employed in chemical laboratories have, we learn from *Science*, made the following recommendations:—(1) That the American Chemical Society, in a manner consistent with its constitution and bye-laws, ask the U.S. Office of Weights and Measures to adopt regulations for the verification of volumetric apparatus which shall be similar in purpose and scope to the regulations of the Kaiserliche Normal-Aichungs-Commission, after due consideration of the criticisms to which the latter have been subjected. (2) That the U.S. Office of Weights and Measures be asked to give special consideration to the question of a standard temperature or temperatures to be adopted for the graduation of volumetric apparatus, and to obtain as far as practicable an expression of opinion from American chemists on this point. (3) That the U.S. Office of Weights and Measures be asked to submit its regulations to the American Chemical Society, or a duly appointed committee thereof, for suggestions before final adoption by that office. (4) That the international kilogram be adopted as the standard mass. (5) That the litre as defined by the International Committee on Weights and Measures be adopted; viz. the volume of the *mass* of a kilogram of pure water at the temperature of maximum density and under a pressure of 760 mm. of mercury. (6) That all density determinations be referred to water at its maximum density and under a pressure of 760 mm. of mercury. (7) That all temperatures be expressed in terms of the hydrogen thermometer of the International Bureau of Weights and Measures. (8) That if any question arise as to the interpretation of the above definitions the decision and standards of the U.S. Office of Standard Weights and Measures shall be accepted by the Society as final.

THE Rev. J. M. Bacon contributes to *Good Words* a general account of his experiments on the audibility of sound in air. It is well known that the report of the explosion of a large meteor may be heard over a great area, although the air at the point where the explosion occurs must be extremely attenuated. Mr. Bacon has endeavoured to imitate the meteoritic explosions to some extent by electrically firing Tonite cartridges suspended below a balloon. An ascent was made, and cartridges were fired at intervals, the altitude of the balloon ranging from 2000 to 3000 feet. The reports were heard by many observers in the parts of London over which the balloon passed, and some interesting conclusions were derived from these observations. In the balloon itself careful readings were taken of the interval of the return of the echo from the earth, and the height the balloon had ascended, while the actual locality over which each cartridge was fired was also noted. From the results obtained, it appeared that there were no aërial echoes, as in Prof. Tyndall's experiments, and that in all cases the reports in their double journey did not travel as quickly as the estimated speed of sound on the earth. "In consequence of these unexpected records," says Mr. Bacon, "another ascent was carried out shortly afterwards from the Crystal Palace when the air was in a totally different condition, and the altitude reached considerably higher. On that day a strange thing happened. The afternoon was an universal drizzle, and the Palace towers had their heads nearly shrouded in the low-lying clouds. On rising the balloon at once made for the west, and entering the cloud shortly reappeared above in glorious sunshine. So for nearly two hours, when, once again descending through the clouds, we found ourselves still going west, but dead over the middle of the river below the fort at Gravesend! All unsuspected by the voyagers, a wind was blowing above the cloud-layer diametrically opposite to that on earth, but causing no impediment to sound thereby. The actual results obtained on the last occasion entirely confirmed those of the former experiment, and differed only in the fact that the reports were apparently heard over a much larger range of country, extending well into the neighbouring counties, and that the reverberations following them, as heard from above, were yet more prolonged than before, sometimes indeed still lingering on after an interval of thirty seconds."

THE Danish Meteorological Office has just published a valuable excerpt paper from its *Aarbog*, giving the meteorological means and extremes for the Faroe, Iceland and Greenland. At Thorshavn (Faroe) the mean monthly values of air temperature during twenty-five years vary from 37°·8 in January and March to 51°·4 in July. The absolute maximum was 70°·2, and the minimum 11°·1. The mean annual rainfall was 63·3 inches, and the greatest fall in twenty-four hours 2·5 inches. For Iceland mean temperature values are given for nineteen years at fifteen stations; the lowest yearly mean is 30°·6 at Moedrudal, and the highest, 41°·0 at Vestmannœ. At Stykkisholm the absolute maximum during twenty-two years was 73°·2 in July, and the minimum – 14°·8 in January. The mean annual rainfall was 24·9 inches, and the greatest fall in twenty-four hours 2·04 inches. For Greenland four stations are given; at the most northern

station, Upernivik, latitude 72°·47, longitude 55°·53 W., the mean temperature of twenty-one years was 16°·2, absolute maximum 64·0, minimum −41°·1. The average rainfall was only 8·9 inches, and the greatest fall in twenty-four hours 2·08 inches.

THE report of the president of the American Museum of Natural History, on the work done during 1898, is a very satisfactory statement of scientific progress, especially the parts of it referring to archæological work and explorations made in connection with the museum. The institution now offers to the student of Mexican and Central American archæology unrivalled opportunities for the study of the sculptures and hieroglyphic writings of the ancient peoples of these portions of America. Noteworthy among the numerous explorations referred to in the report is the Jesup North Pacific Expedition. Before the organisation of this expedition the archæological work conducted on the north-west coast of America was very limited. During the past two years several field parties have carried on very extensive investigations in connection with the Jesup expedition, and have added very considerably to the collections in the museum. During 1897 the field work of the expedition was confined to the coast of British Columbia. In 1898 the work was taken up on a more extended scale. Parties were in the field on the coast of the State of Washington, in the southern interior of British Columbia, and on the Amoor River in Siberia. One of the illustrations in the report, showing a rock carving found in Vancouver Island, where the shell-heaps of the early inhabitants are being investigated, is here reproduced.



Rock carving, Vancouver Island.

ON July 19, for the fifth time during the present century, the city of Rome was damaged by an earthquake. On this last occasion, however, the injuries to buildings were of slight importance, the intensity of the shock having been greaest at Frascati and Marino. Dr. Baratta, who gives a brief description of the earthquake in the *Bollettino* of the Italian Geographical Society, remarks that, in its small meizoseismal area, it resembled the shocks which are characteristic of active and extinct volcanic regions, that it was without doubt of Latian origin, and one of the more prominent manifestations of seismic activity in the Alban Hills.

ONE result of the rapid growth of seismology is the suggestion by Dr. Mario Baratta that provision should be made by insurance against the damage to buildings caused by earthquakes in certain countries. He shows that, since the beginning of the seventeenth century, less than forty earthquakes have been responsible for the deaths of more than 150,000 persons in Italy alone. Moreover, to take but one example, the great loss of life during the Ischian earthquake of 1883 was due to the fact that the buildings had already been damaged by the earthquakes of 1828 and 1881. Dr. Baratta points out some of the conditions that must determine the amount of the premium that should be demanded by insurance societies. The most important is the degree of seismicity of the district; but this would be modified by others, such as the nature of the surface-rocks, the character of the buildings, &c. One advantage of compulsory insurance against earthquakes in a country like Italy would be that partially damaged buildings would be at once rebuilt or repaired, and this would tend to diminish the loss of life in the future.

THE Kew *Bulletin of Miscellaneous Information*, Nos. 152–153, contains the description of a new parasitic disease of the tea-plant which has made its appearance in Ceylon. The fungus which causes it is described by Mr. G. Massee as *Colletotrichum camelliæ*, sp. n.

CONSIDERABLY the most gigantic annual plant ever observed is described by Mr. C. H. Baker in the Kew *Bulletin*. The species in question is *Acnida australis*, belonging to the Amarantaceæ, a native of Florida. The branches attain certainly a length of nearly 22, and probably of 25, feet.

HYBRIDS between plants belonging to different genera are so uncommon that any fresh instance deserves a record. The *Journal of Botany* states that Mr. H. Peirson has found in Kent several examples of an orchid which appears to be a cross betweeen *Orchis maculata* and *Gymnadenia conopsea*.

A BRIEF summary of the changes which have taken place on Vesuvius from 1872 up to June 1899 is given by Dr. R. V. Matteucci in the *Rendiconto* of the Naples Academy, vol. 6, 7.

MR. A. A. CAMPBELL SWINTON sends us a reprint of his lecture read before the Philosophical Society of Glasgow in March last, on "Electric Discharges *in vacuo* and the Rontgen Rays."

THE Institution of Chemistry of Great Britain and Ireland has issued, in the form of a handy octavo pamphlet, its regulations for admission to membership, together with a register of fellows, associates and students for the session 1899–1900, and reprints of examination papers set in the session 1898–99.

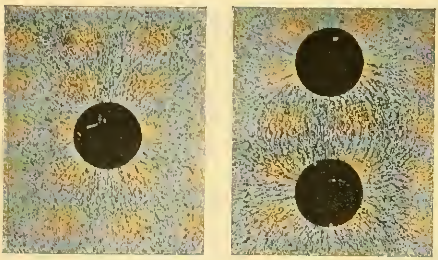
A DETERMINATION of the modulus of elasticity for copper, brass, and steel under small loads by means of interference methods is described by Mr. Charles P. Weston in the *Physical Review* viii. 5, and leads to the important conclusion that for copper and brass, and probably for steel, the ratio between the deflection and a load is a constant quantity for loads ranging from 0·5 gr. to those which would give the bar a permanent set.

DR. AGOSTINO GALDIERI, writing in the *Rendiconto* of the Naples Academy, vol. 6, 7, describes a new alga of the family Palmellaceæ, to which he has given the name *Pleurococcus sulphurarius*, and which he has discovered growing round the

"fumaroli" of the Solfatara at Pozzuoli. This alga is characterised by its remarkable resistance to heat and to the action of sulphuric acid.

MR. WILLIAM FOSTER, jun., writes in the *Physical Review*, viii. 5, on the conductivity and dissociation of some electrolytes, and confirms the values of the depressions of the freezing point as determined by Loomis, within as narrow limits as one should expect. The results also, with a few minor exceptions, conform to the dissociation theory as set forth by Arrhenius, and the author considers that in the present state of physical chemistry we are compelled to look upon this theory as the one that most nearly corresponds with the experimental data, thus affording, at least, a working hypothesis by which the most important generalisations can be made.

To impress upon students the identity of the laws of force for magnetism and electricity at rest, it is necessary to obtain pictures of electrostatic curves analogous to those shown around magnets by means of iron filings. Mr. David Robertson describes in the *Proceedings* of the Royal Society of Edinburgh the way in which such dust figures can be produced, and the accompanying illustrations show the kind of results obtained.



Electrostatic Dust Figures.

A number of materials in the form of powders or short pieces were tried, but the best pictures were given by fine mahogany sawdust. To obtain a picture, a glass plate having one or more pieces of tinfoil stuck upon the under-face, is supported horizontally. Sawdust or other suitable material is spread as uniformly as possible over the plate by means of a sieve or muslin bag, and the tinfoil disc or discs are charged by being connected with a Wimshurst machine in action. The plate has to be tapped to assist the arrangement of the particles, and it is necessary to put the machine out of action when the dust begins to move outwards from the tinfoil. By careful manipulation, distinct indications of the directions of electrostatic lines of force around plane conductors of different shapes, and with like and unlike charges, are produced. The pictures can be fixed by means of a thin layer of paraffin wax on the upper side of the glass plate, or they may be photographed. The two pictures here reproduced from Mr. Robertson's paper show the results obtained with a single disc and with two discs having unlike charges.

A MONOGRAPH on "After-images," by Mr. Shepherd Ivory Franz, forms a notable feature of the *Psychological Review*, iii. 2. This monograph deals, firstly, with an experimental analysis of the conditions affecting the production, the duration, the latent period, the space relations, &c., of the after-image; and, secondly, with a history of the phenomena and their relation to sensation, to imagination and to memory. The experiments described in the first portion were all made in the psychological laboratory of Columbia University, eleven advanced students being selected as subjects. Regarding the historical aspect, it would appear that while after-images have formed the subject of numerous writings dating back from Aristotle's *De Somniis*, the various theories are far from giving a complete explanation of the phenomena.

A FURTHER blow has been dealt to Euler's proof of the Binomial Theorem, by Mr. R. F. Muirhead, writing in the *Proceedings* of the Edinburgh Mathematical Society. This time it is not the omission of convergency considerations that is attacked, but the generalisation of the relation $f(m)f(n)=f(m+n)$ by the permanence of equivalent forms. Mr. Muirhead points out that the function $f(m)(1-\phi(x)\sin m\pi)+\psi(x)\sin m\pi$, where $\phi(x)$, $\psi(x)$ are any functions of $x$, is equal to $(1+x)^m$ when $m$ is a positive integer, and it would be equally valid to infer that functions of this type satisfied the Index Law for all values of $m$ and $n$, which is obviously false for most forms of $\phi(x)$ and $\psi(x)$.

MR. CHARLES S. SCHLICHTER has published, in the nineteenth annual report of the United States Geological Survey, Part ii., a theoretical investigation of the motion of ground waters. In it he investigates the laws of motion of water through the interspaces of an agglomeration of equal spheres, and also discusses the general laws of flow of ground waters. In connection with the motion in horizontal planes, the well-known transformations by conjugate functions are applicable; while the lines of flow in problems relating to the mutual interference of two or more wells are closely analogous to the corresponding lines in two-dimensional hydrodynamical problems involving sources and sinks. The applications of known methods of mathematical analysis to the present problem might with advantage be studied to a greater extent than is done at present.

A GUIDE to the Collection of Scottish Agates in the Edinburgh Museum of Science and Art has been prepared by Mr. J. G. Goodchild. The collection was formed by the late Prof. Heddle, whose explanatory notes on the specimens have been incorporated in the descriptions now given by Mr. Goodchild.

DR. HENRY CHARLES LANG, well known as the author of "The Butterflies of Europe," is bringing out a series of articles in *Science Gossip* on "Butterflies of the Palæarctic Region." The article in the September number deals with the genus Papilio, and is illustrated by fine photographs of *P. machaon*, var. *sphyrus*, Hb., *P. xuthus*, L., type and variety *xuthulus*, Brem., and *P. maackii*, Niéu.

THE *Archives of the Roentgen Ray*—the only journal in which the transactions of the Röntgen Society of London are officially reported—has become an indispensable quarterly for all who are interested in the development of radiography, more especially in relation to medicine. The two numbers (vol. iii. No. 4, and vol. iv. No. 1), just received, contain several excellent reproductions of Röntgen-ray photographs, as well as descriptive text referring to them, and notes and articles on recent researches.

AN illustrated price list of chemical apparatus has been received from Messrs. Brewster, Smith, and Co. Instruments and accessories for all branches of experimental and analytical chemistry appear to be included in the catalogue. With the list we have received a description of a simple spring balance—Moore's Hydrostatic Balance—arranged to illustrate the principle of Archimedes, and specific gravity. The balance should be of service to teachers of the rudiments of physics.

A GLANCE through a catalogue of Röntgen ray apparatus, just issued by the firm of Mr. H. W. Cox, Ltd., shows that the apparatus now available is of a very efficient and compact character. The instruments required to produce successful Röntgen ray pictures are so easily manipulated, and can be obtained at so reasonable a price, that there seems no reason why

every surgeon should not regard an induction coil and accessories as an indispensable part of his general outfit. A noteworthy feature of Mr. Cox's catalogue is a section in which the principles of construction of induction coils are described, and the best methods of using the apparatus explained.

THE Cambridge University Press have issued the following list of additional errata for Lord Kelvin's "Mathematical and Physical Papers," vol. iii.:—Page 33, line 8, for "21,000,000" read "2.100,000"; p. 68, in heading of Table II., for "289°" read "288°"; p. 74, line 7, for "640" read "64"; p. 173, line 6, for "the" (before "quantity") read "a"; p. 226, value of diffusivity of *wood* (col. 4) should be "·0013" instead of "·013"; p. 228, footnote, after "XCVI." insert "Part II."; p 252, line 17, before "being" insert "the whole"; p. 256, line 18, insert parenthesis marks before "since" and after "$\frac{T}{274}$"; p. 348, line 8 from foot, for "$10^{-1}$" read "$10^{-19}$": line 5 from foot, for "second" read "century"; p. 396, line 8 from foot, insert "half" after "than"; p. 398, line 3 of footnote, for "præcendentium" read "præcedentium"; p. 401, footnote, delete "or oblong-rectangle-based"; p. 403, line 25, for "§ 52" read "§ 53"; p. 409, line 5 from foot, for "Caignard" read "Cagniard"; p. 441, line 4, for "$n$" read "$q$": line 8, for "$n^2$" read "$q^2$"; p. 442, line 10 from foot, for "$2\theta$" read "$4\theta$": line 2 from foot, for "$2n$" read "$4n$"; p. 451, line 13, for "forces" read "force"; p. 459, line 5, for "forcives" (first) read "forcive"; p. 478, line 5 of footnote, delete comma after "force"; p. 479, line 8, for "15" read "12": line 9, for "·18" read "·225"; p. 480, line 16, for "of" (after "law") read "if"; p. 483, line 7, for "·18" read "·225."

THE additions to the Zoological Society's Gardens during the past week include a Rhesus Monkey (*Macacus rhesus*) from India, presented by Mr. E. G. Mills; a Short-tailed Vole (*Arvicola agrestis*, var.), British, presented by Mr. A. Thomas; a Leadbeater's Cockatoo (*Cacatua leadbeateri*) from Australia, presented by Lieut.-Colonel G. E. E. Blunt; a Laughing Kingfisher (*Dacelo gigantea*), presented by Mr. Thomas A. de Wolf; eleven Long-nosed Crocodiles (*Crocodilus cataphractus*) from Assay, South Nigeria, presented by Mr. W. J. Bowker; a West African Python (*Python sebae*) from West Africa, presented by Mr. J. S. Budgett; two One-wattled Cassowaries (*Casuarius uniappendiculatus*), a Blue-necked Cassowary (*Casuarius intensus*) from New Guinea, a Little Rock Wallaby (*Petrogale concinna*), two Regent Birds (*Sericulus melinus*) from Australia, a Ring-necked Parrakeet (*Palaeornis torquata*, var.) from India, a Serrated Terrapin (*Chrysemys scripta*) from North America, a Grooved Tortoise (*Testudo calcarata*) from South Africa, deposited.

## *OUR ASTRONOMICAL COLUMN.*

HOLMES' COMET 1899 *d* (1892 III.).—

*Ephemeris for 12h. Greenwich Mean Time.*

| 1899. | R.A. | Decl. | Br. $r^{-2}$ | Br. $(r\Delta^{-2})$ |
|---|---|---|---|---|
| | h. m. s. | ° ′ ″ | | |
| Sept. 14 | 3 9 5 51 | 43 16 46·9 | | |
| 15 | 9 16·48 | 43 29 52·3 | | |
| 16 | 9 25·29 | 43 42 49·4 | | |
| 17 | 9 31 90 | 43 55 38·0 | 0·1777 | 0·05636 |
| 18 | 9 36·31 | 44 8 17·6 | | |
| 19 | 9 38·47 | 44 20 48·0 | | |
| 20 | 9 38·37 | 44 33 8·8 | | |
| 21 | 3 9 35·98 | 44 45 19·7 | 0·1758 | 0·05727 |

On the 20th the comet ceases to move eastward, and commences to travel in a north-westerly path through Perseus.

VANADIUM IN METEORITES.—In a paper contributed to *Mem. Soc. Degli. Spett. Ital.* (vol. xxviii. pp. 113–119), M. M. B. Hasselberg gives the results of an extensive investigation he has been making into the constitution of meteorites. Thirty-one different specimens have been examined, and photographs taken of their spectra when volatilised in the electric arc, the region extending from λ 4268·78 to λ 4444·40. Tables are given showing the relative intensities of the characteristic vanadium lines, the discussion of which leads the author to give the following conclusions:—

(1) The quantity of vanadium present in meteorites is exceedingly small, but the sensible differences found in the several specimens leave no doubt of the reality of its presence. The meteorites of New Concord, Lundsgården, l'Aigle, Kniahynia and Alfianello are cited as showing the metal most easily.

(2) There is a distinct difference between *iron meteorites* and *stony meteorites*, the former containing *no trace* of vanadium, while the latter generally contain it in greater or less quantity.

(3) In the meso-siderites, of intermediate composition, the presence of vanadium is very doubtful, though faint indications are often found.

With regard to the Nejed and Obernkirchen meteorites, which are ferro-siderites, the author states that he has specially looked for the lines found by Lockyer at λλ 4112·5–4119·6, but without success, his vanadium spectrum not containing lines of these wave-lengths. Measures of photographs of comparison spectra of vanadium and Nejed meteorite fail to show the lines, and he gives a list of nine vanadium lines in this region which do not appear in the meteorite, and therefore is led to regard these two as not being exceptions to the rule that iron meteorites contain no trace of vanadium.

CORDOBA PHOTOGRAPHS OF STAR-CLUSTERS.—We have recently received from Dr. S. C. Chandler a volume entitled "Cordoba Photographs," containing the measures and computations made by the late Dr. B. A. Gould, from the photographs of star-clusters obtained at the Argentine National Observatory. Dr. Gould commenced the undertaking in 1872, at the Cordoba Observatory, which was placed at his disposal by the Argentine Government. After his death in 1896 the remaining portions were completed by his assistant, Mr. G. E. Whitaker, who had worked with Dr. Gould for eleven years. The volume is printed in duplicate throughout, in Spanish and English. In the first 41 pages a detailed description is given of the origin of the work, and the method of carrying it out, with full particulars and explanation of the methods of measurement and computation adopted.

Two series of photographs were obtained, one with an object-glass formerly the property of Mr. Rutherford, of 28·6 cm. aperture, and the other with a new glass constructed by Fitz, under Rutherford's superintendence. On Dr. Gould's return to New York in 1885 he had over 1200 plates, besides those of the moon, planets, comets, &c. Of these 281 were fully measured, giving the positions of over 11,000 stars. In addition 315 plates of 96 double stars have also been measured. The material thus made available was so great that it was decided to add no new measures, but proceed with the computations. For this Dr. Gould devised methods of applying corrections for calibration of the micrometer scale, expansion-coefficients of the glass plates, and the reduction of the measures to rectangular coordinates.

The star clusters are restricted to the Southern Hemisphere with only two exceptions, *Pleiades* and *Praesepe*. Each plate was obtained by exposing first for eight minutes, then moving the telescope slightly in R.A. without jar, after which a second exposure of eight minutes was given. Finally the stars were allowed to trail across the plate to give direction of diurnal motion. For some of the plates a third exposure was given instead of obtaining a trail. All the plates were albumenised to prevent distortion of the films, and there has been no trouble from this cause. Various electrical and other contrivances were tried with the telescope, but most of the work was directed by a heavy pendulum as governor. To explain the method of computation, the reduction of a plate of the Pleiades is given with full details of the calculations.

The remainder of the volume, pp. 50–482, consists of the final determined positions of 9144 stars in 37 clusters, each accompanied with its own chapter of explanation. There is a chart of each cluster, showing all the stars considered, to a scale of about 18″ = 1 mm.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

MR. R. P. PARANJPYE, the Indian senior wrangler, has been awarded a special scholarship of 200*l*. by the Secretary of State, partly as a recognition of his remarkable and distinguished success, and partly to enable him to take the M.A. degree.

IT is announced that the annual distribution of medals and prizes obtained by the students of the Royal College of Science will take place in the lecture theatre of the Victoria and Albert Museum on Thursday, October 5, when Prof. A. W. Rücker, F.R.S., will deliver an address.

A COPY of the Calendar of the Durham College of Science, Newcastle-upon-Tyne, has been received. The college forms an important part of the University of the north of England. The degrees of Durham in science and letters and its diplomas in engineering are open to students of the college. The courses of instruction in all natural sciences and in every department of engineering are practical and complete, and the chemical, physical and engineering laboratories are well equipped. In addition to the biological laboratories at the College, a marine biological laboratory has lately been opened at Cullercoats, and by the generosity of the Northumberland Sea Fisheries Committee is available for college students. The agricultural department has been carefully organised, and has been entrusted with the scientific direction of the farm acquired for the purpose of experiment and demonstration by the County Council of Northumberland.

MANY friends of education will regret to learn of the death of Mr. Theodore Beck, principal of the Mahomedan College at Aligarh, at forty years of age. Writing to the *Times*, a friend of the late principal says:—" Men who were at Cambridge in the early eighties will remember Theodore Beck, scholar of Trinity and president of the union, as one of the most conspicuous figures in the University life of the time. He disappeared from the horizon of his English friends, as do all men who go out to India, when he accepted the post of principal in the recently founded college in Aligarh. When he landed in India in 1883 Sir Syed Ahmad was giving practical shape to that great rationalistic movement which was to regenerate the Mussulmans of India. Beck found himself thrown into the midst of a community the bulk of which was sullenly hostile to the English and all their ways. Sir Syed Ahmad saw that his people did not need to acquire the sciences of Europe alone, but also to readjust their ideals by an English standard; for such a change it was necessary not only that they should learn the matter of English text-books, but should also learn to love and admire individual Englishmen and follow them in the ordering of their lives. If Sir Syed was the founder, Theodore Beck was no less certainly the builder of the college in Aligarh and of the large hopes with which it is synonymous. It was he who gave practical form to the generous aspirations in Sir Syed's mind, and who built up the internal organisation of the college so that it has become the type of a new system of collegiate education in India."

## SCIENTIFIC SERIALS.

IN the *Journal of Botany* for August and September, Mr. W. West, jun., contributes a description of some Oscillatorioideæ from the plankton, including a new marine species, *Oscillatoria capitata*, which is figured; Mr. Spencer Le M. Moore, in Part v. of his "Alabastra diversa," describes a number of new species of flowering plants, and Dr. A. B. Rendle several new grasses from South Africa; Mr. J. W. White adds *Rubus Bucknalli*, sp.n., to the already too numerous British brambles.

THE *Journal* of the Royal Microscopical Society for August contains a continuation (Part v.) of Mr. F. W. Millett's report on the recent Foraminifera of the Malay Archipelago collected by Mr. A. Durrand, and a paper by the president, Mr. E. M. Nelson, on the evolution of the fine adjustment of the microscope, in which a new and important adjustment is described, invented by Reichert. Among the more important paragraphs in the summary of current researches relating to zoology, botany and microscopy is a description of a new electrically heated stage, also invented by Reichert.

## SOCIETIES AND ACADEMIES.

### PARIS.

Academy of Sciences, September 4.—M. Maurice Lévy in the chair.—Observations of Swift's Comet (1899 *a*), made with the large equatorial of the Bordeaux Observatory, by MM. G. Rayet and A. Féraud. The observations, twenty-one in number, extend from May 18 to July 15. The mean positions for 1899 are worked out both for the comet and comparison stars. —Remarks by the Director of the "Instituto y observatorio de Marina de San Fernando," offering facilities to astronomers wishing to observe the coming total eclipse of the sun in Spain. —Observations of the planet EP (J. Mascart, August 26, 1899), made at the Observatory of Besançon by M. Chofardet. Note by M. L. J. Gruey. The eight observations given extend from August 29 to September 1, the positions of the comparison stars and the apparent positions of the planets being given.—Observations of the Perseids made at Athens, by M. D. Eginitis.—On the surfaces of the fourth degree which admit an integral of the total differential of the first species, by Mr. Arthur Berry.—On the solidification of hydrogen, by Prof. James Dewar. A tube containing liquid hydrogen, and surrounded by another vacuum jacketed tube containing liquid hydrogen boiling in a vacuum, solidifies, the lower portion being a clear ice-like solid, the upper a solid froth. The density was found to be approximately ·086, the liquid at its boiling point being ·07. Solid hydrogen melts when the pressure of its saturated vapour amounts to 55 mm. The melting point, as determined by two gas thermometers containing hydrogen under reduced pressure, was found to be 16° above the absolute zero at 35 mm. pressure. The lowest temperature attained in these experiments was about $-259°$ C., or 14° absolute.—On the mode of growth in spirals of appendices in course of regeneration in the Arthropods, by M. Edmond Bordage.

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THURSDAY, SEPTEMBER 21, 1899.

## ECLIPSES.

*The Indian Eclipse*, 1898. Edited by E. W. Maunder, F.R.A.S. Pp. xii + 172. (London: Hazell, Watson, and Viney, 1899.)

*The Story of Eclipses.* By G. F. Chambers, F.R.A.S. Pp. viii + 259. (London: George Newnes, 1899.)

NOTWITHSTANDING the fact that the totally eclipsed sun can only be observed for something like three hours in a century, an extensive literature dealing with the phenomena has come into existence. Two distinct branches of the subject may be recognised—one referring chiefly to past eclipses, which have their principal use in chronology, and the other bearing upon the more recent eclipses, in which attempts to extend our knowledge of the sun itself have taken the place of superstitious fear. Of the two books named above, the first belongs to the latter category, while the other is apparently intended to give a simple survey of the whole subject.

The first book forms the report of the two expeditions organised by the British Astronomical Association to observe the total eclipse of January 22, 1898, and gives an account of the objects and results of the observations made. The organisation of the expedition, combining science with pleasure, appears to have been in capable hands, and the Association is to be congratulated on the fact that some of those who took part in the observations gave the first place to science. Mr. Maunder's party at Talni was especially active, but Mr. Bacon's party appears to have arrived at Buxar too late to undertake anything very serious. The duplication of results, which inevitably followed from the fact that the eclipse was well visible to observers all along the line, to a certain extent reduces the value of the work at any particular station, each party probably being able to claim but little in the way of novel results which would not otherwise have been brought to light. Thus it is that the more specially valuable results of these expeditions are those obtained by Mr. Evershed and Mrs. Maunder—the former with the ultra-violet region of his photographs of the so-called "flash" and coronal spectra, and the latter indicating the best means of photographing the long extensions of the corona. Miscellaneous observations of the usual character are included in the report, as well as a chapter of hints for future work. No effort has been spared to make the report attractive; the general story of the expeditions forms very interesting reading, and the explanatory matter is very clear and concise, while the numerous illustrations from photographs—not all of scientific value, however—are beautifully reproduced. The chief scientific interest undoubtedly belongs to Mr. Evershed's fine photographs, taken with a very modest prismatic camera, and the full discussion of these wlll doubtless yield valuable results.

Mr. Chambers's book has been written primarily for the benefit of the English-speaking people who may expect to witness the phenomena of the total eclipse of May 28, 1900, in Spain or the United States. A very small part, however, is given to the information which seems to us what the average probable observer will desire to know the greater part of the book being a sort of descriptive catalogue of eclipses, ancient and modern, including lunar eclipses. A complete want of proportion is, in fact, shown throughout; for instance, more than a dozen pages are taken up by an attempt to prove that the backward motion of the shadow on the dial of Ahaz was caused by a partial eclipse, while only two pages are given to the three important eclipses of 1893, 1896, and 1898. The author appears to have entirely failed to grasp the enormous advances which have lately been made, and leaves his readers in complete ignorance of the more important observations which now occupy the attention of astronomers during eclipses; thus, less than a single page is occupied by references to the spectroscope, and most of the statements made are now known to be erroneous. Finally, in his desire to satisfy the thirst for knowledge which it is one of the main objects of this series of books to create, the author refers almost entirely to works which comparatively few will be able to read, and quite omits to mention even the late Mr. Ranyard's classical compilation. The only redeeming features of the book, bearing in mind its more particular aim, are the thirty-three pages of matter describing the general phenomena of a total eclipse, and the appendix indicating how one may get to Spain or Portugal for the next eclipse.

## A FRENCH WRITER ON CLASSIFICATION.

*Aperçus de Taxinomie Générale.* Par J.-P. Durand (de Gros). Pp. 265. (Paris: Félix Alcan, 1899.)

EVERY scientific worker who takes in hand the task of classifying the objects of his study comes thereby into relation with the domain of logic and metaphysics. Whether this be done consciously or unconsciously, the classifier cannot avoid raising and dealing with questions which are the concern of philosophy as well as of physical science. The author of the book before us, starting from the position that all taxinomy (which form he prefers, on etymological grounds, to the more usual "taxonomy") must conform to logical requirements, proceeds to give a careful and elaborate analysis of the principles of logical division so far as they are involved in the classifications of science. To this he adds a free criticism, mainly from the logical point of view, of the labours of scientific taxinomists; and in the last place he furnishes some suggestions for the guidance of future workers in the same field. His preliminary analysis, if not very profound in its reasoning, is marked by the lucidity and good sense so constantly to be met with in writers of his nation. It does not add very much, except in clearness and fulness of treatment, to what is to be found in most standard works on logic, nor does it always avoid insisting at considerable length on the trite and obvious. This, however, evidently arises from the anxiety of the author to make himself thoroughly understood, and to allow no omission or ambiguity in the steps of his argument. He has certainly succeeded in expressing himself so clearly that whatever may be thought of his doctrine, no mistake can arise as to his meaning.

With regard to the critical portion of the work, it must be granted that most of the author's strictures are, from his own point of view, well founded. Nevertheless, it may be questioned whether the logical blots he contrives to hit

in the work of Mill, Littré, Bichat and others, have really the grave importance or have produced the disastrous results which he attributes to them. Mill's use of certain terms, such as "abstract" and "concrete general," is no doubt open to serious objection; but there is much likelihood that his conceptions on these points did not really differ from those of his critic; and the same *mutatis mutandis* may probably be said of the logical slips of Bichat and Haeckel. It would be unfair to accuse the author of pedantry, but at the same time it is not certain that he allows sufficiently for that faculty of the human mind which frequently leads it to conclusions practically sound by processes that are logically quite indefensible.

The constructive part of the book is hardly so strong as the critical. Here, however, M. Durand does excellent service in emphasising the point, even now imperfectly grasped by many systematists, that no classification of organisms can be really natural unless it proceeds on a phylogenetic basis. Where the phylogeny is unknown, a natural classification is so far impossible. In such cases an artificial classification, based on characters more or less arbitrarily selected, may be provisionally adopted as a substitute; and, so long as it is not treated as final, may answer all ordinary purposes without detriment to the advance of knowledge. From failure to recognise the practical value of such temporary expedients, M. Durand, as it seems to us, is led to adopt an unduly pessimistic tone with regard to he future of biological taxinomy. For a long time to come zoologists and botanists will doubtless have to proceed by the method of successive approximation; and even if the ideal result should be finally unattainable, enough will probably be gained to satisfy all demands but those of the logical purist.

M. Durand's able and acute commentary may be studied with profit by all who engage in taxinomic work themselves, or who wish to appreciate that of others The most serious charge we have to bring against him is that of making scientific molehills into logical and metaphysical mountains. F. A. D.

## OUR BOOK SHELF.

*Die Welt als That. Umrisse einer Weltansicht auf naturwissenschaftlichen Grundlage.* By J. Reinke. Pp. iv + 483. (Berlin: Gebrüder Paetel, 1899.)

IN this work Prof. Reinke sets forth his philosophic and scientific creed, his conceptions of nature and the universe, of plant, beast, man, and God. The book is divided into five parts. The first is entitled "Subject and Object of the Study of Nature," and discusses things and ideas, time and space, causality, chance, intelligence, and other metaphysical questions. The second part, under the heading of "The World-Stage," deals with the material universe and with the conceptions of matter, force and direction. The third part discusses "The Nature of Life," and in thirteen chapters treats of the cell, irritability, reproduction and heredity, adaptations, the origin of life, and kindred problems. In the fourth part, "Darwinism," the author, after giving an outline of the theory of natural selection and of the views of Nägeli and Weismann, states his own conclusions with regard to this subject. The fifth part, entitled "Natural Science and the Conception of God," discusses monism and dualism, theism, pantheism and atheism, and the first chapter of Genesis.

It is clear, from this brief summary of the contents of the book, that the field covered by it is a wide one. It must suffice here, therefore, to draw attention to the main results or conclusions reached by the author, which are in reality summed up in the last sentence of the book—"Im Anfang war die That"—"In the Beginning was the Deed." The solution to each and all of the great mysteries of science is to be found in the direct creative act of an intelligent being. One such act and deed created the material universe. A second gave rise to the first living organic substance, to protoplasm, where previously only the inorganic had existed. And a third act seems to be necessary to explain the origin of intelligence; "that matter thinks is certainly something other than that matter assimilates and breathes." These alleged creative acts are compared to the Days of Creation of the Mosaic Cosmogony, which the author considers "one of the greatest intellectual feats of history," combining both truth and poetry. As a proof of the greatness of Moses, the reader is referred to his statue at Rome by Michael Angelo, "since only one of the greatest of the mortal race of men could inspire the great artist of the Renaissance to such a work."

Prof. Reinke does not, it will be seen, arrive at very strikingly original conclusions, but it is something of a novelty to see a scientific man at the present day putting forward such propositions as the last message of science. He is frankly a dualist and considers monism "an exploded attempt to comprehend the world," the outcome of the natural effort of thinking man "to refer all explanations of things to the simplest possible principles." It is not, however, necessary to seek for unity; "the limit to be attained may just as well be duality, trinity, or a higher multiplicity." Dualism is "the ripe fruit of the studies set forth in this book." "In nature intelligent forces are to be distinguished as dominant from energetic forces as subservient; in organisms both are inseparably combined." Those who may wish for further information as to the processes of reasoning by which the author arrives at these conclusions must be referred to the work itself. E. A. M.

*La Liquéfaction aes Gaz: Méthodes nouvelles—Applications.* Par J. Cauro, Docteur ès Sciences. Pp. 83 (Paris: Gauthier-Villars, 1899.)

DR. CAURO'S book is good enough to make one wish it were better. Its chief faults are negative, and may be summed up in the words excessive concentration. When it is stated that within the limits of eighty pages the author gives an analysis of the theory of refrigeration and the changes of physical state involved, a description of the methods and apparatus of scientific investigators and of the machines employed in industrial work, a historical *résumé* of the progress of this branch of knowledge, and a review of the actual and possible applications of cold, it will be easily imagined that most of the work must be too sketchy to be of real use to any one. If refrigeration were recognised as a special subject in the examinations for some degree, Dr. Cauro's work is sufficiently accurate and up to date to make it a very good book for getting up the subject, though even from this point of view excessive brevity has led to some errors, as when the apparatus figured on p. 24 is described as a modification of that on p. 23, whereas it depends on a radically different process for attaining the same end. For popular reading, both the descriptive and the historical parts are too brief to be interesting, and are not even intelligible without more knowledge than such reading implies. Practical men of science, and practical makers of industrial machines, would have found the book very useful in reminding and suggesting, if every statement and description had been accompanied by full references to the original papers and other sources of information, so that those who are interested in any

special branch of the subject would have had a guide to full and intelligible records of detail. Such references are nowhere given. The book is worth the extra clerical work that their insertion would have involved; but as it stands it is of little use to any one. Who, for instance, is helped by this brief paragraph on p. 64?—"Concentration of sea-water.—The process is employed in some northern salt-works, and is more economical than concentration by heat."

## LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### Movement of Sea-Gulls with a Coming Change of Weather.

IN your issue of September 7, p. 439, I read with some interest the note by Prince Kropotkin on the movements of sea-gulls upon our coasts having some connection with a coming change of weather; and that at Margate on Saturday, August 26, it was noticed such a movement was going on, the gulls passing from west of that place to the south coast, to meet, as the fishermen say, a south-west wind. It may be of interest, and as in a measure confirmatory of such a movement going on just before a marked change of weather conditions, that on Sunday evening at 5.30 o'clock six large sea-gulls passed over this place, 400 feet above the sea (situated 2½ miles due east of Cranleigh), flying in a direction south-west by south. We very seldom see gulls so far inland, but I have seen them before flying in much the same course. The direction in which these were heading would have taken them to the coast near Portsmouth, distant about thirty-five miles; and at the elevation at which they were flying, the English Channel was no doubt visible to them, for the South Downs were at the time particularly clear.

H. H. GODWIN-AUSTEN.

Nore, Hascombe, Godalming, September 12.

### Thermometric Scales for Meteorological Use.

As Mr. Buchanan has called attention to the advantages of the Fahrenheit thermometric scale as compared with the Centigrade, I will state that at the Blue Hill Meteorological Observatory, while the metric system has been adopted for research work the Fahrenheit thermometer has been retained. The chief reason is the same as that given by Mr. Buchanan, namely, the occurrence of the zero in such a place as to make nearly half the readings below zero. The reading of the scale first upward and then downward is awkward, and the averaging of the results troublesome, besides making in each case a source of error. If the Centigrade thermometer is ever adopted by the English-speaking nations, I would suggest that, at least for meteorological uses, the freezing point of water be marked 273° on the scale, and the boiling point 373°. This would give meteorologists at once the temperatures which are concerned in the change of volume of gases, and embodied in a large number of the formulas used in meteorological work. At the same time it would for ever get rid of the troublesome inverted scale. In printing the results, 200 could be put at the top of the printed column, and the excess over 200 be printed at its proper place in the column. In this way most of the observed temperatures could be expressed in whole degrees by two figures as at present.

The metric system will soon be adopted, I trust, by all the English-speaking peoples. Besides the advantages of the relations of all the different portions of the system to each other, and the ease of converting smaller measures into fractions of larger measures of the same kind, every one must recognise the advantage of having one uniform system of measurement throughout the world. Almost every civilised nation except those speaking English have now adopted the metric system, and I cannot believe the English will long hold aloof.

H. HELM CLAYTON.

Blue Hill Meteorological Observatory, September 5.

## THE NEW LUNAR PHOTOGRAPHIC ATLAS

MM. LŒWY and Puiseux have recently communicated to the Paris Academy of Sciences[1] continuations of their valuable descriptions of the unequalled lunar photographs they are now obtaining by means of the large Equatorial Coudé. As in the case of the three Parts of the Atlas already published, they accompany their descriptions with a discussion of the bearings of the new results obtained on the general questions of selenology. We have on previous occasions given an account of Parts i.,[2] ii.,[3] and iii.,[4] and we now give a full translation of the recent communications.

The first, which deals with the description of the photographs contained in the fourth Part, runs as follows:—

The fourth Part comprises, like the preceding ones, a positive on the scale of the original negative, and six enlargements on different scales. All these photographs, except one, deal with the waning moon, and for the first time we see the eastern edge illuminated to a certain extent. We propose to briefly indicate the most striking characteristics of the regions represented.

Plate *d* is a general photograph, in which nearly two-thirds of the visible hemisphere is illuminated, and distinguishes itself at first sight from similar positives already published. Here the work of reproduction has been directed in such a manner as to give, as far as possible, the details contained in the most brilliant parts of the lunar disc. But we also establish an intrinsic difference between the eastern and western halves of the moon, so far as the distribution of mountains and plains is concerned. Up to now we have seen the seas presenting themselves like a chain of circular basins, occupying only a zone of ordinary size on both sides of a great circle; they now take a sudden and considerable development in the direction of latitude. It appears that a large depression encountered the first, like the Atlantic Ocean across the Mediterranean deeps of our globe. These depressed parts, generally of sombre colour, are not of a uniform shade, and the darkest spots accumulate near the mountainous border. There is cause to consider these regions as more depressed than the neighbouring parts of the seas, and their distribution, as they are indicated in Plates *b* and *d*, is in accordance with what we know of the ways of the submarine depths on the terrestrial globe.

We have already noted, with regard to the third Part, the white borders which encircle Kepler and Copernicus, and which prolong themselves in different directions in long rectilinear streams. We find them here again illuminated more normally, and detaching themselves in consequence in a clearer manner. The systems of Euclid, Aristarchus, Olbers, Byrgius and Tycho, equally visible on Plate *d*, appear to us to be, like the first, depositories of volcanic cinders, carried to great heights by violent eruptions and disseminated by variable atmospheric currents. They imply with no less clearness different periods of activity, separated by intervals of repose. All the walled plains which serve as origin to a collection of such trails show under an oblique illumination a fairly equal uniform wall of some altitude. So soon as the sun has risen a little on their horizon, they shine with an intense whiteness, sometimes accentuated by the presence of a dark areola at the source of the trails. The great dimensions of Copernicus reveal other interesting facts; thus we see that the white tint is far from being equally distributed on the whole length of the walled plain, that the diameter of this surpasses by a great deal the length of the trails, and

[1] *Comptes rendus*, June 26 and July 3.
[2] NATURE, vol. lii. p. 435, 1895.
[3] *Ibid.*, vol. lvi. p. 280, 1897.
[4] *Ibid.*, vol. lix. p. 304, 1899.

that the latter are more often directed tangentially to the rampart than in a line with the centre. All these circumstances tend to make one consider the little orifices situated either on the central mass, on the ridge which limits the walled plain, or in the immediate neighbourhood, as the real seat of eruptive activity, which one might have been tempted to attribute to the orifice itself.

Plate XVIII., which comprises the southern pole, gives us a contour deformed by important excrescences. The Tycho region shows itself, at the setting as well as at the rising of the sun, rich in prominent ridges, which serve as limits to the walled plains they meet, and impose on them polygonal or elongated forms. A more attentive examination shows the existence of two superposed systems of parallel ridges, which cut the surface up into quadrilaterals. The influence of these alignments has made itself felt, not only in the primitive formation of the walled plains, but in the successive annexations which have often constituted a new wall, at some distance behind the first, as can be seen in Clavius. No trace of these angular fashions are to be found in the little parasite orifices, of recent date, which uniformly tend towards the perfect circle. Blancanus, without approaching the extent of Clavius, is classed with it by its clearness, its great depth, by the indented shadow which reproduces inequalities of the crest, and would lend itself admirably to measurements of altitude. In spite of the great differences of level noted, this region is very uniform in tint. This characteristic is due to the white colour which the Tycho trails throw over the whole.

Taken from the same cliché as the preceding one, Plate XIX. offers quite another aspect. We see plains prevailing here, sprinkled with islands and brilliant craters, furrowed with prominent veins or crevasses, and covered in certain parts by large trails which emanate from Copernicus and Tycho. We have already become familiar with this region in Plate VIII. of the Atlas. The comparison of the photographs dealing with very different phases is instructive. We note again the relative permanency of the bright areolæ, and the periodic variabiliy of the dark spots. The phenomenon of the encroachment on and of the submersion and final destruction of the walled plains can be observed here in all its degrees, and we meet with many cases where the depression has engulfed a half of the enclosure and the interior plain without affecting the rest of the rampart, or even the central crater.

Plate XX. takes us back again to the western hemisphere, to a part where the relief shows itself with extreme energy. Numerous local sinkings have here reduced the capacity of the crust, without its having to submit (to follow the contraction of the liquid centre) to a general sinking, accompanied by submersion. Various indications prove, however, that a movement of this sort has been begun. Thus, the great fracture of the Altai mountains, visible near the western edge of the photograph, skirts at a distance the sea of Nectar, and seems to prepare for its extension.

Another depressed space, also very vast, occupies the central part of the photograph, but has not succeeded in defining its contour, nor in determining the appearance of a sea. Most of the walled plains involved in this movement have amongst them a very marked family likeness, with a flat bottom and regular rampart. Those which have remained outside have kept their primitive physiognomy better, and retained in a great number of cases their central craters. Apart from these lines of circular depression, we see certain rectilinear tracts of primitive rocks extending over great stretches. As elevations they have formed an obstacle to the expansion of the walled plains. As depressions they have, on the contrary, made it easier, and many of them have transformed themselves into regular chaplets of small craters.

Plate XXI. conducts one still further west, up to the illuminated edge of the moon. The characteristics already verified in the Mare Humorum reappear in the Mare Crisium in a perhaps more accentuated degree; there are rarity of irregularities on the interior plains, elevation and regularity of the wall, persistence of a concentric terrace remaining adherent to the edge, accumulation of dark spots near the periphery. Quite near, the Mare Fecunditatis shows, besides its network of prominent ridges, large undulations of a rather convex character, like those of terrestrial seas. The intermediate plateaus, poor in walled plains, seem to be the fairly well preserved testimony of an ancient period. In the neighbourhood of Taruntius it presents a smooth region, probably levelled by an abundant volcanic deposit. Everywhere else it is furrowed with deep valleys, which tend to orient themselves along the meridian, and this direction seems to impose itself more and more on approaching the illuminated edge. A double system of alignments, cutting each other almost at right angles, prevails in the Pyrenees, which form the terminator at the upper part of the photograph, and Pétavius reveals itself, as well as many other walled plains of the first order, inscribed in a quadrilateral. Nearer the equator, Langrenus, with its double central mountain, its concentric terraces, its divergent trails, affords a quantity of eruptive characteristics which Copernicus and Tycho perhaps alone reunite in the same degree.

Collected on the next photograph (Pl. XXII.) we find, in a very limited space, five remarkable specimens of the great crevasses of the crust, that of Sabine, Sosigenes, Pliny, Ariadæus and Hyginus. The first three follow more or less the borders of a sea, and may be considered as separating a depressed region from the strip which has remained adherent to the mountainous plateau. The fissure of Ariadæus, prolonged a great stretch without regard to the relief of the surface, cutting many transversal chains, appears to date from an epoch when the crust was still disjoined and mobile in the tangential direction.

Hyginus presents, besides, quite a series of circular enlargements, which transform, as it were, a crevasse into a chaplet of craters.

The plain which surrounds Arago contains two characteristic examples of formations extremely rare at the present time. They are vast intumescences, 15 km. to 20 km. in size, in which the sinking of the central part would give rise to the ordinary physiognomy of the walled plains.

The last sheet may be recommended as illustrating well the structure of the mountainous masses of the moon, saved by some means, and left in relief after the formation of the seas.

Draughtsmen have had to content themselves here, in presence of the multitude of details, and of their variability of aspect, with a conventional figuration, where few objects, except those which form projections, could be named or identified. Our photograph renders a much more precise topographic description possible. The most peaked part of the Apennines and the Alps show a number of summits which can be recognised on the sheets of the preceding Parts, in spite of the change of incidence of the light. We see a characteristic appearing, noted by geographers as special to chains of the most recently elevated mountains, where the erosion has not had time to destroy the primitive constitution; it is a marked dissymmetry in the relief, throwing the highest summits to one side, and dividing the mass into two parts of very unequal average slopes.

So much for the descriptive matter. We now come to

the second communication to the Academy, which deals with the conclusions which the authors base on the photographs.

(1) There exists, from the point of view of relief, a general similarity between the seas of the moon and the plateaus which are covered to-day by terrestrial oceans.

In these, convex surfaces are more frequent than concave basins, thrown back generally towards the limit of the depressed space. In the same way, the seas of the moon present, generally at the edges, rather pronounced depressions. In one case, as in the other, we observe normal deformations of a shrinking globe shielded from the erosive action of rain, which tends, on the contrary, in all the abundantly watered parts of the earth to make the concave surfaces predominate. The explanation of this structure, such as is admitted to-day by geologists, seems to us equally valid for the moon.

(2) In order to find an equivalent resemblance in the raised parts of the surface, one ought to be able to establish on the moon features effaced by the volcanic eruptions, on the earth those which have disappeared by erosion. We can supply this in a certain measure by comparing on the one side the lunar ranges relatively poor in walled-plains, on the other by terrestrial ranges of recent elevation, where the initial structure can be reconstituted without too much effort. We then observe, on the chains which surround the lunar seas, as on those which enclose the Mediterranean basin, the contrast of a rapid interior slope and of a slightly inclined exterior one. This contrast is often so clear on the moon, that the cause may be put down to a rupture of the strata, without waiting for any stratigraphical confirmation, which up to the present time has not been realised.

(3) The greater development in the seas of the eastern half of the lunar disc shows that the phenomena of depression must have manifested themselves at an earlier period than in the western part. If it were so, one must hold that the crust had there imprisoned gases in relatively greater quantities, and opposed a smaller resistance to their expansion. It is, in fact, on the east side that the isolated orifices show themselves in greater numbers on the surface of the seas, and that the volcanic forces have created radial systems stretching in all directions.

The development of these phenomena has necessarily required a considerable time, and there is reason to admit that these plains, solidified before those of the western part of the moon, have long ago reached a configuration little different from that which they possess to-day.

(4) The formation of the seas begins by the sinking of a vast region, which is soon isolated by a circular fracture. This fracture does not generally mark the future limit of the sea. We can mention cases where the depressed space entirely escapes submersion; others where the central part only is invaded; others, finally, where the primitive enclosure is covered, and where the sea increases by annexing marginal belts. It is by a series of analogous stages that the largest walled-plains seem to have arrived at their actual dimensions.

(5) The epoch of the solidification of a sea does not coincide with that of the positive fixing of the level in the central part. This may lower itself still more, and determine by its retreat the formation of a new crevasse, parallel like the first, to the borders of the sea.

(6) The new photographs, as well as the first, furnish us with several specimens of great walled-plains where the solidification, due to the progressive cooling, has been effected at three or even four different levels, separated by intervals of several kilometres. The modern depressions, compared with the ancient ones, are nearly always less extensive, and have a more rapid interior slope and a more regular circular form. The more modern ones, such as those which open on the bottom of Longomontanus already very depressed, present no trace of the surrounding bulge; that is to say, that their appearance does not seem to have been preceded by an upheaval.

(7) Nevertheless, this intumescence phenomenon of the lunar crust, considered by us to be the habitual preliminary of the formation of walled-plains, has in certain exceptional but well verified cases given rise to convex figures, of which the central part has not sunk.

(8) We have previously indicated how it was possible in a fairly large number of cases, to assign the relative age of the walled plains according to the state of preservation of their ramparts, and the more or less complete submersion of their interior cavity. In the parts invaded by the trails, we can judge, by another characteristic, the epoch of the interior solidification of the walled-plain. It is convenient to place in the first line and in order of age the plains which have received and retained a uniform white covering; then those which only present some feeble and late trails, in the form of bands; lastly, those which have remained completely clear, and encroach to-day by their sombre tint on the neighbouring region.

This chronological criterion, clearer than that which depends on the state of preservation of the ridges, informs us also of the relative time of solidification in the different parts of the seas. Unfortunately, it fails us in the fairly numerous regions to which the trails have not extended.

(9) In general, the great systems of trails cover indistinctly all the undulations of the soil in their path. This circumstance has already permitted us to conclude that the formidable volcanic eruptions, of which the moon has been the theatre, belong to a recent time in the history of our satellite. They must have been preceded by the almost complete solidification of the seas, and of the bottom of the walled-plains. It seems to us the same fact must be taken into consideration in the problem, so often discussed, of the atmosphere of the moon. In fact, not only have these eruptions set at liberty great quantities of gas or vapours, but the diffusion of cinders to great distances infers a gaseous envelope of a certain density.

It is true that the relative feebleness of gravity helps one to understand their initial ascent to a considerable altitude. However, the resistance of the atmosphere must have been sufficient to retard the fall of this dust during its transport over a distance of more than 1000 kilometres.

Has the time which has elapsed since the great eruptions sufficed to bring about the total disappearance of this gaseous envelope? One is inclined to doubt it, on examining the mechanism of the two principal causes which could have operated in this direction. The crust, already everywhere solidified, could only have absorbed the gases slowly and with difficulty. The loss in space of molecules with a velocity great enough to carry them into the sphere of attraction of another body became of necessity less and less in proportion as the temperature became lower. We find, therefore, in the examination of the lunar surface serious ground to believe that there exists, at the present time, a residue of atmosphere of which the detection, surrounded as it is with great difficulties, may yet be realised.

This induction adds itself to that which has been furnished, as we have seen by the discussion of eclipses and occultations. The care which astronomers have for some years given to the study of these phenomena, and the great number of occultations of small stars which may now be observed at each total eclipse, give reason to hope that this discussion may soon be resumed on a new basis, and lead to more precise conclusions.

## *THE DOVER MEETING OF THE BRITISH ASSOCIATION.*

*Dover, September* 19.

THE meeting of the British Association at Dover, which concludes this week, has been on the whole a great success, especially when the size of the town and the fact that it is the most ambitious effort the town has ever made are considered. The number of members and associates present falls little short of 1400, and amongst these are included an unusually large number of the chief representatives of science. The proceedings at the various Sections have been interesting, though there has been no very startling announcement made at any of them, but very good work has been done. Though there is, perhaps, no longer as great a necessity as formerly for the missionary side of the Association's work, yet its usefulness as a common meeting ground for representatives of science in every branch can never be overrated. The necessity for some such central gathering point as the Association affords becomes the greater as science becomes more and more specialised.

The Presidential Addresses in the various Sections have reached a very high standard of excellence. Prof. Poynting's address in Section A was a masterpiece of exposition; that of Mr. Horace Brown in Section B was remarkable for the light it throws on many of the obscure problems so interesting alike to botanists and chemists, and contained much original work. The Mechanical Science Section had a most interesting address from its President, Sir W. H. White. The Geological Section arranged to have its address on Saturday, September 16, when the French Association paid its visit to Dover. A very large gathering of a cosmopolitan character assembled to hear Prof. Geikie discourse on geological time. The vote of thanks was moved by Lord Lister and seconded by the President of the French Geological Society.

The Presidential Addresses to which reference has just been made were delivered for the most part on Thursday and Friday, arrangements being made so that no two addresses were appointed for the same time. Thus all the Sectional meetings at the time of the Presidential Addresses were well filled.

On Thursday afternoon the first social function took place in the College grounds, where the Chairman of the College Council, headmaster and master entertained over one thousand guests. The band of the Royal Artillery and the Westminster Glee Singers enlivened the proceedings. The balloon ascent did not take place owing to a high N.E. wind prevailing, which would have taken the balloon into the North Sea. On Friday, however, the wind had fallen a little, and a non-scientific balloon ascent took place. The balloon descended later on at Gravelines, and a message of greeting from the Headmaster of Dover College was delivered to the Mayor on behalf of the President of the British Association. On Friday evening a most interesting though short address was delivered by Prof. Richet, of Paris, who proved himself to be an adept both in oratory and in the art of scientific exposition. The vote of thanks was moved by Lord Lister and seconded by Sir W. T. Thiselton-Dyer in most appropriate terms. A smoking concert followed which reflected great credit on its organisers.

The reception of the members of the French Association took place on Saturday. About 280 members arrived at the Admiralty Pier about 9.30, and were received by the President of the British Association and those members who were Correspondents and Associates of the Academy of Sciences. The military were also represented at the landing on the pier. Some disappointment seems to have been felt by the spectators that a larger number of members of the British Association were not present, but this feeling was not experienced by the French visitors, who were delighted with the warmth and cordial nature of their greeting, especially when Sir Michael Foster kissed Dr. Brouardel on both cheeks. Sir Michael Foster in his speech at the luncheon wittily referred to this act as the embracing of the daughter by the mother. Seven tram cars then conveyed the members off to the Town Hall, where the Mayor of Dover, accompanied by the Corporation, officially received the visitors, and various speeches were delivered. The gathering then broke up, and various Sections were visited. At two o'clock some 800 guests sat down to an elaborate luncheon in a marquee near the reception-room. After the lunch speeches were delivered, and toasts of a most cordial nature were proposed. The Presidents of the two Associations, the Mayors of Dover and Boulogne, the Under-Secretary for War (Mr. G. Wyndham), the member for Dover, being amongst the chief speakers. Everything passed off with great cordiality and enthusiasm. After the lunch the whole assembly was photographed in the College grounds. The French visitors then paid a visit to the Castle, where they were shown the chief objects of interest by the Rev. S. P. H. Statham, Senior Chaplain to the Forces, and author of a recently published history of Dover. The visitors were taken back to Boulogne by a special steamer (the *Empress*) at six o'clock. In the evening an interesting military tattoo took place on the sea-front, which was lavishly illuminated for the occasion. On Sunday there were services at most of the Dover churches, and a large number of members of the Association visited Canterbury, where an organ recital was given in the afternoon, in addition to the special services and sermons announced for the occasion. In Dover College Chapel, the Rev. A. H. Stevens gave a very interesting and well-arranged organ recital in the afternoon also.

On Monday there was a garden-party at the Park, which attracted a large gathering of people and was a perfect success in every way. The feature of the evening was the lecture by Prof. Fleming on the centenary of the electric current, which was illustrated by numerous exceedingly interesting experiments. Prof. Fleming for a couple of hours kept his large audience listening in rapt attention to the masterly exposition of his subject. To the general public, perhaps the most interesting part was the demonstration of the Marconi wireless telegraphy, by which messages were exchanged with Dr. Brouardel and with the Goodwin Lightship.

On Wednesday there is to be a visit to Canterbury to meet one hundred members of the French Association. There will be a lunch, which will be attended by about one hundred of the leading members of the British Association, in addition to the French visitors. Previously to the visit to Canterbury, the concluding general meeting will be held, when a vote of thanks to the Mayor and Corporation for their reception of the Association will be moved by Lord Lister, and seconded by Sir Frederick Bramwell. The vote will be acknowledged by the Town Clerk on behalf of the Mayor, and by Mr. W. H. Pendlebury, who is local secretary jointly with Colonel Knocker. A second vote of thanks will be proposed to the Council and Headmaster of Dover College for their kindness in allowing the use of their rooms and the College grounds, which have added so much to the interest of the meeting. Votes of thanks will also be given to those who have offered hospitality to members of the Association, and especially to the naval and military authorities who have in various ways helped to make the meeting a success.

On Thursday, if the weather is propitious, a large number of members, including the chief representatives of the various branches of science, are expected to visit Boulogne. This will conclude the Dover meeting of the British Association, which will be looked back upon with great interest by most of those who have attended it.

The chief members of the French Association who visited Dover were Dr. Brouardel, the president; Dr. Aigre, the Mayor of Boulogne; Dr. Boushard. the ex-president; MM. Dislere, also ex-president; Gariel, secretary; Lôir (nephew of Pasteur), also secretary; M. Bergoine, Professor of Medicine at Bordeaux; M. Namy, Membre de l'Institute; M. Giard, professor at the Sorbonne; Dr. Ferraud; M. Collignon; M. Farjon; M. de Guerne, ex-president; Dr. de Walcourt; Dr. Dufour, of Lausanne, and others. It will be seen that the French visitors were representative men.

W. H. Pendlebury.

*Work of the General Committee.*

The report of the council of the Association was read and adopted at the first meeting of the general committee. It announced that after due consideration the council had resolved to recommend the general committee to contribute the sum of 1000*l*. to the National Antarctic Expedition, and that the grant be given out of the accumulated funds of the Association, and not out of the sum allocated to annual grants. The report also stated that the following resolutions, referred to the council by the general committee for consideration and action if desirable, have been considered and acted upon:—

(1) That having regard to the letter of December 15, 1897, from Sir E. Maunde Thompson, the council be requested to take further action with regard to a bureau of ethnology, by renewing the correspondence with the Trustees of the British Museum.

A committee was accordingly appointed for the purpose of conferring with the officers of the British Museum. The President has also been in correspondence with the Marquis of Salisbury regarding this matter, and the council have the pleasure to announce that satisfactory arrangements have been made for the establishment of such a bureau, and that Lord Salisbury has directed that reports prepared by officers in the various Protectorates under the administration of the Foreign Office be forwarded to the British Museum.

(2) That the council be requested to consider the desirability of representing to the Colonial Government that the early establishment of a magnetic observatory at the Cape of Good Hope would be of the highest utility to the science of terrestrial magnetism, especially in view of the Antarctic expeditions which are about to leave Europe, and that the observatory should be established at such a distance from electric railways and tramways as to avoid all possibility of disturbance from them.

The question having been considered, the council requested the President to make the necessary representation to the Colonial Government. The council have received a minute of the Government of Cape Colony, through the High Commissioner, stating that while Ministers have much sympathy with the suggestion to establish a magnetic observatory, and do not overlook the scientific and practical aspects of the project, they do not regard as practicable the immediate provision by the colony of funds for the carrying out of the scheme.

(3) That the council be requested to consider the advisability of urging Her Majesty's Government to place at the disposal of the Seismological Committee of the British Association a suitable building for the housing of apparatus for continuous seismological observations.

A committee which was appointed to report on this resolution stated that in their opinion it is desirable that a central station should be established, and recommended the council to request the Government to place a suitable building at the disposal of the Seismological Committee which could be used as a station for carrying on observations and would serve as a centre for the stations (now twenty-three in number) in various parts of the world which, at the request of the committee, have been supplied with seismographic apparatus of the pattern they have recommended.

The council decided to reappoint the committee for the purpose of reporting further on the best situation for the proposed central seismological station and on the cost of its maintenance.

(4) That the council be requested to urge strongly on the Indian Government the desirability, in the interests both of administration and of science, to promote an inquiry, under the direction of skilled anthropologists, into the physical and mental characteristics of the various races throughout the Empire, including their institutions, customs and traditions, and a carefully organised photographic survey.

A committee which was appointed to consider this question reported that in their opinion the resolution in its present form is of too comprehensive and costly a character to justify the council in submitting it to the Indian Government.

(5) That the council be recommended to issue the collected reports on the North-Western tribes of Canada in a single volume at a moderate price, reprinting so many of the reports as may be necessary.

The council resolved that the reports be not reprinted.

(6) That the council be requested to bring under the notice of the Admiralty the importance of securing systematic observations upon the erosion of the sea coast of the United Kingdom, and that the co-operation of the coastguard might be profitably secured for this purpose.

A committee having been appointed to report on the above resolution, recommended that the council inquire whether the Admiralty would be willing to arrange that observations of a simple character on changes in the sea coast be recorded and reported by the coastguards. The committee pointed out that if the Admiralty consented to carry out this proposal it would be necessary to appoint a committee for the purpose of drawing up a scheme of instruction for the observers, making arrangements for starting the work, and subsequently examining from time to time such localities as may seem to require special attention. This recommendation having been adopted by the council, the president was requested to approach the Admiralty upon the subject, and in response a reply was received from the Admiralty stating that my Lords saw no objection to this proposal, as the required observations could be made by the men in the ordinary course of their duty.

At the second meeting of the general committee invitations for the meeting of the Association in 1902 were received, and the officers were appointed for next year's meeting at Bradford, to commence on Wednesday, September 5. The meeting will be held at Glasgow in 1901. Representatives of the cities of Belfast and Cork invited the Association to meet at one of these places in 1902; but the president explained that no definite answer could yet be given to the invitations.

Upon the proposal of Lord Lister, seconded by Sir Archibald Geikie, Sir William Turner, F.R.S., was appointed President-elect for the meeting at Bradford in 1900.

Sir J. Evans proposed that the following persons be asked to serve as vice-presidents at the Bradford meeting:—The Earl of Scarborough (Lord Lieutenant of the West Riding), the Duke of Devonshire, the Marquis of Ripon, the Bishop of Ripon, Lord Masham, the Mayor of Bradford, the Hon. H. E. Butler, Sir A. Binnie, Prof. Rücker, and Prof. Thorpe.

Sir Norman Lockyer seconded the resolution, which was carried unanimously.

The general secretaries (Sir W. Roberts-Austen and Prof. Schäfer), the assistant general secretary (Mr. Griffith), and the general treasurer (Prof. Carey Foster) were re-elected.

The following is a synopsis of the grants of money made for scientific purposes by the general committee, at the meeting just concluded:—

*Mathematics.*

| | £ |
|---|---|
| *Rayleigh, Lord—Electrical Standards (£300 in hand) ... | 25 |
| *Judd, Prof. J. W.—Seismological Observations (£9 5s. 4d. in hand) ... | 60 |
| *FitzGerald, Prof. G. F.—Radiation in a Magnetic Field | 25 |
| *Rücker, Prof. A. W.—Magnetic Force on board Ship .. | 10 |
| *Callendar, Prof. H. L.—Meteorological Observatory, Montreal ... | 20 |
| *Kelvin, Lord—Tables of Mathematical Functions ... | 75 |

*Chemistry.*

| | |
|---|---|
| *Hartley, Prof. W. N.—Relation between Absorption Spectra and Constitution of Organic Bodies ... | 30 |
| *Roscoe, Sir H. E.—Wave-length Tables ... | 5 |
| *Reynolds, Prof. J. E.—Electrolytic Quantitative Analysis ... | 5 |
| Miers, Prof. H. A.—Isomorphous Sulphonic Derivatives of Benzene ... | 20 |
| Neville, Mr. F. H.—The Nature of Alloys ... | 30 |

*Geology.*

| | |
|---|---|
| *Hull, Prof. E.—Erratic Blocks (£6 in hand) ... | |
| *Geikie, Prof. J.—Photographs of Geological Interest ... | 10 |
| *Dawkins, Prof. W. B.—Remains of Elk in the Isle of Man ... | 5 |
| *Dawson, Sir J. W.—Pleistocene Fauna and Flora in Canada ... | 10 |
| *Lloyd-Morgan, Prof. C.—Ossiferous Caves at Uphill (£8 in hand) ... | 10 |
| Watts, Prof. W. W.—Movements of Underground Waters of Craven... | 40 |
| Scharff, Dr.—Exploration of Irish Caves... | 20 |

*Zoology.*

| | |
|---|---|
| *Herdman, Prof. W. A.—Table at the Zoological Station, Naples ... | 100 |
| *Bourne, Mr. G. C.—Table at the Biological Laboratory, Plymouth ... | 20 |
| *Woodward, Dr. H.—Index Generum et Specierum Animalium... | 50 |
| *Newton, Prof.—Migration of Birds ... | 15 |
| Lankester, Prof. E. Ray.—Plankton and Physical Conditions of the English Channel ... | 40 |
| *Newton, Prof.—Zoology of the Sandwich Islands ... | 100 |
| Sedgwick, Mr. A.—Coral Reefs of the Indian Region... | 30 |

*Geography.*

| | |
|---|---|
| Murray, Sir John—Physical and Chemical Constants of Sea Water ... | 100 |

*Economic Science and Statistics.*

| | |
|---|---|
| Price, Mr. L. L.—Future Dealings in Raw Produce ... | 5 |
| Sedgwick, Prof. H.—State Monopolies in other Countries (£13 13s. 6d. in hand) ... | |

*Mechanical Science.*

| | |
|---|---|
| *Preece, Sir W. H.—Small Screw Gauge (£17 1s. 2d. in hand) ... | |

*Anthropology.*

| | |
|---|---|
| *Evans, Mr. A. J.—Silchester Excavation ... | 10 |
| *Penhallow, Prof. D. P.—Ethnological Survey of Canada | 50 |
| *Tylor, Prof. E. B.—New Edition of "Anthropological Notes and Queries" ... | 40 |
| *Garson, Dr. J. G.—Age of Stone Circles (balance in hand) ... | |
| *Read, Mr. C. H.—Photographs of Anthropological Interest ... | 10 |
| *Brabrook, Mr. E. W.—Mental and Physical Condition of Children ... | 5 |
| Read, Mr. C. H.—Ethnography of the Malay Peninsula | 25 |

*Physiology.*

| | |
|---|---|
| *Schäfer, Prof. E. A.—Physiological Effects of Peptone... | 20 |
| Schäfer, Prof. E. A.—Comparative Histology of Suprarenal Capsules ... | 20 |
| *Gotch, Prof. F.—Comparative Histology of Cerebral Cortex ... | 5 |
| Gotch, Prof. F.—Electrical Changes in Mammalian Nerves ... | 20 |
| Starling, Dr.—Vascular Supply of Secreting Glands . | 10 |

*Botany.*

| | |
|---|---|
| *Darwin, Mr. F.—Assimilation in Plants (£6 6s. 8d. in hand) ... | |
| *Farmer, Prof. J. B.—Fertilisation in Phæophyceæ ... | 20 |

*Corresponding Societies.*

| | |
|---|---|
| *Meldola, Prof. R.—Preparation of Report... | 20 |
| | £1115 |

* Re-appointed.

## SECTION C.

GEOLOGY.

OPENING ADDRESS BY SIR ARCHIBALD GEIKIE, D.C.L., D.SC., F.R.S., PRESIDENT OF THE SECTION.

AMONG the many questions of great theoretical importance which have engaged the attention of geologists, none has in late years awakened more interest or aroused livelier controversy than that which deals with time as an element in geological history. The various schools which have successively arisen—Cataclysmal, Uniformitarian, and Evolutionist—have had each its own views as to the duration of their chronology, as well as to the operations of terrestrial energy. But though holding different opinions, they did not make these differences matter of special controversy among themselves. About thirty years ago, however, they were startled by a bold irruption into their camp from the side of physics. They were then called on to reform their ways, which were declared to be flatly opposed to the teachings of natural philosophy. Since that period the discussion then started regarding the age of the earth and the value of geological time has continued with varying animation. Evidence of the most multifarious kind has been brought forward, and arguments of widely different degrees of validity have been pressed into service both by geologists and palæontologists on one side, and by physicists on the other. For the last year or two there has been a pause in the controversy, though no general agreement has been arrived at in regard to the matters in dispute. The present interval of comparative quietude seems favourable for a dispassionate review of the debate. I propose, therefore, to take, as perhaps a not inappropriate subject on which to address geologists upon a somewhat international occasion like this present meeting of the British Association at Dover, the question of Geological Time. In offering a brief history of the discussion, I gladly avail myself of the opportunity of enforcing one of the lessons which the discussion has impressed upon my own mind, and to point a moral which, as it seems to me, we geologists may take home to ourselves from a consideration of the whole question. There is, I think, a practical outcome which may be made to issue from the controversy in a combination of sympathy and co-operation among geologists all over the world. A lasting service will be rendered to our science if by well-concerted effort we can place geological dynamics and geological chronology on a broader and firmer basis of actual experiment and measurement than has yet been laid.

To understand aright the origin and progress of the dispute regarding the value of time in geological speculation, we must take note of the attitude maintained towards this subject by some of the early fathers of the science. Among these pioneers none has left his mark more deeply graven on the foundations of modern geology than James Hutton. To him, more than to any other writer of his day, do we owe the doctrine of the high antiquity of our globe. No one before him had ever seen so clearly the abundant and impressive proofs of this remote antiquity recorded in the rocks of the earth's crust. In these rocks he traced the operation of the same slow and quiet processes which he observed to be at work at present in

* Re-appointed.

gradually transforming the face of the existing continents. When he stood face to face with the proofs of decay among the mountains, there seems to have arisen uppermost in his mind the thought of the immense succession of ages which these proofs revealed to him. His observant eye enabled him to see "the operations of the surface wasting the solid body of the globe, and to read the unmeasurable course of time that must have flowed during those amazing operations, which the vulgar do not see, and which the learned seem to see without wonder" ("Theory of the Earth," vol. i. p. 108). In contemplating the stupendous results achieved by such apparently feeble forces, Hutton felt that one great objection he had to contend with in the reception of his theory, even by the scientific men of his day, lay in the inability or unwillingness of the human mind to admit such large demands as he made on the past. "What more can we require?" he asks in summing up his conclusions; and he answers the question in these memorable words: "What more can we require? Nothing but time. It is not any part of the process that will be disputed; but after allowing all the parts, the whole will be denied; and for what?—only because we are not disposed to allow that quantity of time which the ablution of so much wasted mountain might require" (*op. cit.* vol. ii. p. 329).

Far as Hutton could follow the succession of events registered in the rocky crust of the globe, he found himself baffled by the closing in around him of that dark abysm of time into which neither eye nor imagination seemed able to penetrate. He well knew that, behind and beyond the ages recorded in the oldest of the primitive rocks, there must have stretched a vast earlier time, of which no record met his view. He did not attempt to speculate beyond the limits of his evidence. "I do not pretend," he said, "to describe the beginning of things; I take things such as I find them at present, and from these I reason with regard to that which must have been (*op. cit.* vol. i. p. 173, *note*). In vain could he look, even among the oldest formations, for any sign of the infancy of the planet. He could only detect a repeated series of similar revolutions, the oldest of which was assuredly not the first in the terrestrial history, and he concluded, as "the result of this physical inquiry, that we find no vestige of a beginning, no prospect of an end" (*op. cit.* vol. i. p. 200).

This conclusion from strictly geological evidence has been impugned from the side of physics, and, as further developed by Playfair, has been declared to be contradicted by the principles of natural philosophy. But if it be considered on the basis of the evidence on which it was originally propounded, it was absolutely true in Hutton's time and remains true to-day. That able reasoner never claimed that the earth has existed from all eternity, or that it will go on existing for ever. He admitted that it must have had a beginning, but he had been unable to find any vestige of that beginning in the structure of the planet itself. And notwithstanding all the multiplied researches of the century that has passed since the immortal "Theory of the Earth" was published, no relic of the first condition of our earth has been found. We have speculated much, indeed, on the subject, and our friends the physicists have speculated still more. Some of the speculations do not seem to me more philosophical than many of those of the older cosmogonists. As far as trustworthy evidence can be drawn from the rocks of the globe itself, we do not seem to be nearer the discovery of the beginning than Hutton was. The most ancient rocks that can be reached are demonstrably not the first-formed of all. They were preceded by others which we know must have existed, though no vestige of them may remain.

It may be further asserted that, while it was Hutton who first impressed on modern geology the conviction that for the adequate comprehension of the past history of the earth vast periods of time must be admitted to have elapsed, our debt of obligation to him is increased by the genius with which he linked the passage of these vast periods with the present economy of nature. He first realised the influence of time as a factor in geological dynamics, and first taught the efficacy of the quiet and unobtrusive forces of nature. His predecessors and contemporaries were never tired of invoking the more vigorous manifestations of terrestrial energy. They saw in the composition of the land and in the structure of mountains and valleys memorials of numberless convulsions and cataclysms. In Hutton's philosophy, however, "it is the little causes, long continued, which are considered as bringing about the greatest changes of the earth" ("Theory of the Earth," vol. ii. p. 205).

And yet, unlike many of those who derived their inspiration from his teaching, but pushed his tenets to extremes which he doubtless never anticipated, he did not look upon time as a kind of scientific fetich, the invocation of which would endow with efficacy even the most trifling phenomena. As if he had foreseen the use that might be made of his doctrine, he uttered this remarkable warning: "With regard to the effect of time, though the continuance of time may do much in those operations which are extremely slow, where no change, to our observation, had appeared to take place, yet, where it is not in the nature of things to produce the change in question, the unlimited course of time would be no more effectual than the moment by which we measure events in our observations" (*op. cit.* vol. i. p. 44).

We thus see that in the philosophy of Hutton, out of which so much of modern geology has been developed, the vastness of the antiquity of the globe was deduced from the structure of the terrestrial crust and the slow rate of action of the forces by which the surface of the crust is observed to be modified. But no attempt was made by him to measure that antiquity by any of the chronological standards of human contrivance. He was content to realise for himself and to impress upon others that the history of the earth could not be understood, save by the admission that it occupied prolonged though indeterminate ages in its accomplishment. And assuredly no part of his teaching has been more amply sustained by the subsequent progress of research.

Playfair, from whose admirable "Illustrations of the Huttonian Theory" most geologists have derived all that they know directly of that theory, went a little further than his friend and master in dealing with the age of the earth. Not restricting himself, as Hutton did, to the testimony of the rocks, which showed neither vestige of a beginning nor prospect of an end, he called in the evidence of the cosmos outside the limits of our planet, and declared that in the firmament also no mark could be discovered of the commencement or termination of the present order, no symptom of infancy or old age, nor any sign by which the future or past duration of the universe might be estimated ("Illustrations of the Huttonian Theory, § 118). He thus advanced beyond the strictly geological basis of reasoning, and committed himself to statements which, like some made also by Hutton, seem to have been suggested by certain deductions of the French mathematicians of his day regarding the stability of the planetary motions. His statements have been disproved by modern physics; distinct evidence, both from the earth and the cosmos, has been brought forward of progress from a beginning which can be conceived, through successive stages to an end which can be foreseen. But the disproof leaves Hutton's doctrine about the vastness of geological time exactly where it was. Surely it was no abuse of language to speak of periods as being vast, which can only be expressed in millions of years.

It is easy to understand how the Uniformitarian school, which sprang from the teaching of Hutton and Playfair, came to believe that the whole of eternity was at the disposal of geologists. In popular estimation, as the ancient science of astronomy was that of infinite distance, so the modern study of geology was the science of infinite time. It must be frankly conceded that geologists, believing themselves unfettered by any limits to their chronology, made ample use of their imagined liberty. Many of them, following the lead of Lyell, to whose writings in other respects modern geology owes so deep a debt of gratitude, became utterly reckless in their demands for time, demands which even the requirements of their own science, if they had adequately realised them, did not warrant. The older geologists had not attempted to express their vast periods in terms of years. The indefiniteness of their language fitly denoted the absence of any ascertainable limits to the successive ages with which they had to deal. And until some evidence should be discovered whereby these limits might be fixed and measured by human standards, no reproach could justly be brought against the geological terminology. It was far more philosophical to be content, in the meanwhile, with indeterminate expressions, than from data of the weakest or most speculative kind to attempt to measure geological periods by a chronology of years or centuries.

In the year 1862 a wholly new light was thrown on the question of the age of our globe and the duration of geological time by the remarkable paper on the Secular Cooling of the Earth communicated by Lord Kelvin (then Sir William Thomson) to the Royal Society of Edinburgh (*Trans. Roy. Soc. Edin.*, vol. xxiii., 1862). In this memoir he first developed his now

well-known argument from the observed rate of increase of temperature downwards from the surface of the land. He astonished geologists by announcing to them that some definite limits to the age of our planet might be ascertained, and by declaring his belief that this age must be more than 20 millions, but less than 400 millions, of years.

Nearly four years later he emphasised his dissent from what he considered to be the current geological opinions of the day by repeating the same argument in a more pointedly antagonistic form in a paper of only a few sentences, entitled, "The Doctrine of Uniformity in Geology briefly refuted" (*Proc. Roy. Soc. Edin.*, vol. v. p. 512, December 18, 1865).

Again, after a further lapse of about two years, when, as President of the Geological Society of Glasgow, it became his duty to give an address, he returned to the same topic and arraigned more boldly and explicitly than ever the geology of the time. He then declared that "a great reform in geological speculation seems now to have become necessary," and he went so far as to affirm that "it is quite certain that a great mistake has been made—that British popular geology at the present time is in direct opposition to the principles of natural philosophy" (*Trans. Geol. Soc. Glasgow*, vol iii., February 1868, pp. 1, 16). In pressing once more the original argument derived from the downward increase of terrestrial temperature, he now reinforced it by two further arguments, the one based on the retardation of the earth's angular velocity by tidal friction, the other on the limitation of the age of the sun.

These three lines of attack remain still those along which the assault from physics is delivered against the strongholds of geology. Lord Kelvin has repeatedly returned to the charge since 1868, his latest contribution to the controversy having been pronounced two years ago.[1] While his physical arguments remain the same, the limits of time which he deduces from them have been successively diminished. The original maximum of 400 millions of years has now been restricted by him to not much more than 20 millions, while Prof. Tait grudgingly allows something less than 10 millions ("Recent Advances in Physical Science," p. 174).

Soon after the appearance of Lord Kelvin's indictment of modern geology in 1868, the defence of the science was taken up by Huxley, who happened at the time to be President of the Geological Society of London. In his own inimitably brilliant way, half seriously, half playfully, this doughty combatant, with evident relish, tossed the physical arguments to and fro in the eyes of his geological brethren, as a barrister may flourish his brief before a sympathetic jury. He was willing to admit that "the rapidity of rotation of the earth *may* be diminishing, that the sun *may* be waxing dim, or that the earth itself *may* be cooling." But he went on to add his suspicion that "most of us are Gallios, 'who care for none of these things,' being of opinion that, true or fictitious, they have made no practical difference to the earth, during the period of which a record is preserved in stratified deposits" (Presidential Address, *Quart. Journ. Geol. Soc.*, 1869).

For the indifference which their advocate thus professed on their behalf most geologists believed that they had ample justification. The limits within which the physicist would circumscribe the earth's history were so vague, yet so vast, that whether the time allowed were 400 millions or 100 millions of years did not seem to them greatly to matter. After all, it was not the time that chiefly interested them, but the grand succession of events which the time had witnessed. That succession had been established on observations so abundant and so precise that it could withstand attack from any quarter, and it had taken as firm and lasting a place among the solid achievements of science as could be claimed for any physical speculations whatsoever. Whether the time required for the transaction of this marvellous earth-history was some millions of years more or some millions of years less did not seem to the geologists to be a question on which their science stood in antagonism with the principles of natural philosophy, but one which the natural philosophers might be left to settle at their own good pleasure.

For myself, I may be permitted here to say that I have never shared this feeling of indifference and unconcern. As far back as the year 1868, only a month after Lord Kelvin's first presentation of his threefold argument in favour of limiting the age of the earth, I gave in my adhesion to the propriety of restricting the geological demands for time. I then showed that even the phenomena of denudation, which, from the time of Hutton downwards, had been most constantly and confidently appealed to in support of the inconceivably vast antiquity of our globe, might be accounted for, at the present rate of action, within such a period as 100 millions of years.[1] To my mind it has always seemed that whatever tends to give more precision to the chronology of the geologist, and helps him to a clearer conception of the antiquity with which he has to deal, ought to be welcomed by him as a valuable assistance in his inquiries. And I feel sure that this view of the matter has now become general among those engaged in geological research. Frank recognition is made of the influence which Lord Kelvin's persistent attacks have had upon our science. Geologists have been led by his criticisms to revise their chronology. They gratefully acknowledge that to him they owe the introduction of important new lines of investigation, which link the solution of the problems of geology with those of physics. They realise how much he has done to dissipate the former vague conceptions as to the duration of geological history, and even when they emphatically dissent from the greatly restricted bounds within which he would now limit that history, and when they declare their inability to perceive that any reform of their speculations in this subject is needful, or that their science has placed herself in opposition to the principles of physics, they none the less pay their sincere homage to one who has thrown over geology, as over so many other departments of natural knowledge, the clear light of a penetrating and original genius.

When Lord Kelvin first developed his strictures on modern geology he expressed his opposition in the most uncompromising language. In the short paper to which reference has already been made he announced, without hesitation or palliation, that he "briefly refuted" the doctrine of Uniformitarianism which had been espoused and illustrated by Lyell and a long list of the ablest geologists of the day. The severity of his judgment of British geology was not more marked than was his unqualified reliance on his own methods and results. This confident assurance of a distinguished physicist, together with a formidable array of mathematical formulæ, produced its effect on some geologists and palæontologists who were not Gallios. Thus, even after Huxley's brilliant defence, Darwin could not conceal the deep impression which Lord Kelvin's arguments had made on his mind. In one letter he wrote that the proposed limitation of geological time was one of his "sorest troubles." In another, he pronounced the physicist himself to be "an odious spectre" (Darwin's "Life and Letters," vol. iii. pp. 115, 146).

The same self-confidence of assertion on the part of some, at least, of the disputants on the physical side has continued all through the controversy. Yet when we examine the three great physical arguments in themselves, we find them to rest on assumptions which, though certified as "probable" or "very sure," are nevertheless admittedly assumptions. The conclusions to which these assumptions lead must depend for their validity on the degree of approximation to the truth in the premisses which are postulated.

Now it is interesting to observe that neither the assumptions nor the conclusions drawn from them have commanded universal assent even among physicists themselves. If they were as self-evident as they have been claimed to be, they should at least receive the loyal support of all those whose function it is to pursue and extend the applications of physics. It will be remembered, however, that thirteen years ago Prof. George Darwin, who has so often shown his inherited sympathy in geological investigation, devoted his presidential address before the Mathematical Section of this Association to a review of the three famous physical arguments respecting the age of the earth. He summed up his judgment of them in the following words: "In considering these three arguments I have adduced some reasons against the validity of the first (tidal friction); and have endeavoured to show that there are elements of uncertainty surrounding the second (secular cooling of the earth); nevertheless they undoubtedly constitute a contribution of the first importance to physical geology. Whilst, then, we may protest against the precision with which Prof. Tait seeks to deduce results from them, we are fully justified in following Sir William Thomson, who says that "the existing state of things on the earth, life on the earth—all geological history showing con-

[1] "The Age of the Earth," being the Annual Address to the Victoria Institute, June 2, 1897. *Phil. Mag.*, January 1899, p. 66.

[1] *Trans. Geol. Soc. Glasgow*, vol. iii. (March 26, 1868), p. 189. Sir W. Thomson acknowledged my adhesion in his reply to Huxley's criticism. *Op. cit.* p. 221.

tinuity of life—must be limited within some such period of past time as 100,000,000 years" (*Rep. Brit. Assoc.*, 1886, p. 517).

More recently Prof. Perry has entered the lists, from the physical side, to challenge the validity of the conclusions so confidently put forward in limitation of the age of the earth. He has boldly impugned each of the three physical arguments. That which is based on tidal retardation, following Mr. Maxwell Close and Prof. Darwin, he dismisses as fallacious. In regard to the argument from the secular cooling of the earth, he contends that it is perfectly allowable to assume a much higher conductivity for the interior of the globe, and that this assumption would vastly increase our estimate of the age of the planet. As to the conclusions drawn from the history of the sun, he maintains that, on the one hand, the sun may have been repeatedly fed by infalling meteorites, and that, on the other, the earth, during former ages, may have had its heat retained by a dense atmospheric envelope. He thinks that "almost anything is possible as to the present internal state of the earth," and he concludes in these words: "To sum up, we can find no published record of any lower maximum age of life on the earth, as calculated by physicists, than 400 millions of years. From the three physical arguments, Lord Kelvin's higher limits are 1000, 400, and 500 million years. I have shown that we have reasons for believing that the age, from all these, may be very considerably under-estimated. It is to be observed that if we exclude everything but the arguments from mere physics, the *probable* age of life on the earth is much less than any of the above estimates; but if the palæontologists have good reasons for demanding much greater times, I see nothing from the physicist's point of view which denies them four times the greatest of these estimates" (NATURE, vol. li. p. 585, April 18, 1895).

This remarkable admission from a recognised authority on the physical side re-echoes and emphasises the warning pronounced by Prof. Darwin in the address already quoted—"at present our knowledge of a definite limit to geological time has so little precision that we should do wrong to summarily reject any theories which appear to demand longer periods of time than those which now appear allowable" (*Rep. Brit. Assoc.*, 1886, p. 518).

This "wrong," which Prof. Darwin so seriously deprecated, has been committed, not once, but again and again in the history of this discussion. Lord Kelvin has never taken any notice of the strong body of evidence adduced by geologists and palæontologists in favour of a much longer antiquity than he is now disposed to allow for the age of the earth. His own three physical arguments have been successively re-stated, with such corrections and modifications as he has found to be necessary, and no doubt further alterations are in store for them. He has cut off slice after slice from the allowance of time which at first he was prepared to grant for the evolution of geological history, his latest pronouncement being that "it was more than twenty and less than forty million years, and probably much nearer twenty than forty."[1] But in none of his papers is there an admission that geology and palæontology, though they have again and again raised their voices in protest, have anything to say in the matter that is worthy of consideration.

It is difficult satisfactorily to carry on a discussion in which your opponent entirely ignores your arguments, while you have given the fullest attention to his. In the present instance, geologists have most carefully listened to all that has been brought forward from the physical side. Impressed by the force of the physical reasoning, they no longer believe that they can make any demands they may please on past time. They have been willing to accept Lord Kelvin's original estimate of 100 millions of years as the period within which the history of life upon the planet must be comprised, while some of them have even sought in various ways to reduce that sum nearer to his lower limit. Yet there is undoubtedly a prevalent misgiving, whether in thus seeking to reconcile their requirements with the demands of the physicist they are not tying themselves down within limits of time which on any theory of evolution would have been insufficient for the development of the animal and vegetable kingdoms.

It is unnecessary to recapitulate before this Section of the British Association, even in briefest outline, the reasoning of geologists and palæontologists which leads them to conclude that the history recorded in the crust of the earth must have required for its transaction a much vaster period of time than that to which the physicists would now restrict it.[1] Let me merely remark that the reasoning is essentially based on observations of the present rate of geological and biological changes upon the earth's surface. It is not, of course, maintained that this rate has never varied in the past. But it is the only rate with which we are familiar, which we can watch and in some degree measure, and which, therefore, we can take as a guide towards the comprehension and interpretation of the past history of our planet.

It may be, and has often been, said that the present scale of geological and biological processes cannot be accepted as a trustworthy measure for the past. Starting from the postulate, which no one will dispute, that the total sum of terrestrial energy was once greater than it is now and has been steadily declining, the physicists have boldly asserted that all kinds of geological action must have been more vigorous and rapid during bygone ages than they are to-day; that volcanoes were more gigantic, earthquakes more frequent and destructive, mountain-upthrows more stupendous, tides and waves more powerful, and commotions of the atmosphere more violent, with more ruinous tempests and heavier rainfall. Assertions of this kind are temptingly plausible and are easily made. But it is not enough that they should be made; they ought to be supported by some kind of evidence to show that they are founded on actual fact and not on mere theoretical possibility. Such evidence, if it existed, could surely be produced. The chronicle of the earth's history, from a very early period down to the present time, has been legibly written within the sedimentary formations of the terrestrial crust. Let the appeal be made to that register. Does it lend any support to the affirmation that the geological processes are now feebler and slower than they used to be? If it does, the physicists, we might suppose, would gladly bring forward its evidence as irrefragable confirmation of the soundness of their contention. But the geologists have found no such confirmation. On the contrary, they have been unable to discover any indication that the rate of geological causation has ever, on the whole, greatly varied during the time which has elapsed since the deposition of the oldest stratified rocks. They do not assert that there has been no variation, that there have been no periods of greater activity, both hypogene and epigene. But they maintain that the demonstration of the existence of such periods has yet to be made. They most confidently affirm that whatever may have happened in the earliest ages, in the whole vast succession of sedimentary strata nothing has yet been detected which necessarily demands that more violent and rapid action which the physicists suppose to have been the order of nature during the past.

So far as the potent effects of prolonged denudation permit us to judge, the latest mountain-upheavals were at least as stupendous as any of older date whereof the basal relics can yet be detected. They seem, indeed, to have been still more gigantic than those. It may be doubted, for example, whether among the vestiges that remain of Mesozoic or Palæozoic mountain-chains any instance can be found so colossal as those of Tertiary times, such as the Alps. No volcanic eruptions of the older geological periods can compare in extent or volume with those of Tertiary and recent date. The plication and dislocation of the terrestrial crust are proportionately as conspicuously displayed among the younger as among the older formations, though the latter, from their greater antiquity, have suffered during a longer time from the renewed disturbances of successive periods.

As regards evidence of greater violence in the surrounding envelopes of atmosphere and ocean, we seek for it in vain among the stratified rocks. Among the very oldest formations of these islands, the Torridon sandstone of North-west Scotland presents us with a picture of long-continued sedimentation, such as may be seen in progress now round the shores of many a mountain-girdled lake. In that venerable deposit, the enclosed pebbles are not mere angular blocks and chips, swept by a sudden flood or destructive tide from off the surface of the land, and huddled together in confused heaps over the floor of the sea. They have been rounded and polished by the quiet operation of running water, as stones are rounded and polished

[1] "The Age of the Earth," Presidential Address to the Victoria Institute for 1897, p. 10; also in *Phil. Mag.*, January 1899.

[1] The geological arguments are briefly given in my Presidential Address to the British Association at the Edinburgh Meeting of 1892. The biological arguments were well stated, and in some detail, by Prof. Poulton, in his Address to the Zoological Section of the Association at the Liverpool Meeting of 1896.

now in the channels of brooks or on the shores of lake and sea. They have been laid gently down above each other, layer over layer, with fine sand sifted in between them, and this deposition has taken place along shores which, though the waters that washed them have long since disappeared, can still be followed for mile after mile across the mountains and glens of the North-west Highlands. So tranquil were these waters that their gentle currents and oscillations sufficed to ripple the sandy floor, to arrange the sediment in laminæ of current-bedding, and to separate the grains of sand according to their relative densities. We may even now trace the results of these operations in thin darker layers and streaks of magnetic iron, zircon, and other heavy minerals, which have been sorted out from the lighter quartz-grains, as layers of iron-sand may be seen sifted together by the tide along the upper margins of many of our sandy beaches at the present day.

In the same ancient formation there occur also various intercalations of fine muddy sediment, so regular in their thin alternations, and so like those of younger formations, that we cannot but hope and expect that they may eventually yield remains of organisms which, if found, would be the earliest traces of life in Europe.

It is thus abundantly manifest that even in the most ancient of the sedimentary registers of the earth's history, not only is there no evidence of colossal floods, tides and denudation, but there is incontrovertible proof of continuous orderly deposition, such as may be witnessed to-day in any quarter of the globe. The same tale, with endless additional details, is told all through the stratified formations down to those which are in the course of accumulation at the present day.

Not less important than the stratigraphical is the palæontological evidence in favour of the general quietude of the geological processes in the past. The conclusions drawn from the nature and arrangement of the sediments are corroborated and much extended by the structure and manner of entombment of the enclosed organic remains. From the time of the very earliest fossiliferous formations there is nothing to show that either plants or animals have had to contend with physical conditions of environment different, on the whole, from those in which their successors now live. The oldest trees, so far as regards their outer form and internal structure, betoken an atmosphere neither more tempestuous nor obviously more impure than that of to-day. The earliest corals, sponges, crustaceans, molluscs, and arachnids were not more stoutly constructed than those of later times, and are found grouped together among the rocks as they lived and died, with no apparent indication that any violent commotion of the elements tried their strength when living, or swept away their remains when dead.

But, undoubtedly, most impressive of all the palæontological data is the testimony borne by the grand succession of organic remains among the stratified rocks as to the vast duration of time required for their evolution. Prof. Poulton has treated this branch of the subject with great fulness and ability. We do not know the present average rates of organic variation, but all the available evidence goes to indicate their extreme slowness. They may conceivably have been more rapid in the past, or they may have been liable to fluctuations according to vicissitudes of environment.[1] But those who assert that the rate of biological evolution ever differed materially from what it may now be inferred to be, ought surely to bring forward something more than mere assertion in their support. In the meantime, the most philosophical course is undoubtedly followed by those biologists who in this matter rest their belief on their own experience among recent and fossil organisms.

So cogent do these geological and palæontological arguments appear, to those at least who have taken the trouble to master them, that they are worthy of being employed, not in defence merely, but in attack. It seems to me that they may be used with effect in assailing the stronghold of speculation and assumption in which our physical friends have ensconced themselves and from which, with their feet, as they believe, planted well within the interior of the globe and their heads in the heart of the sun, they view with complete unconcern the efforts made by those who endeavour to gather the truth from the surface and crust of the earth. That portion of the records of terrestrial history which lies open to our investigation has been diligently studied in all parts of the world. A vast body of facts has been gathered together from this extended and combined research. The chronicle registered in the earth's crust, though not complete, is legible and consistent. From the latest to the earliest of its chapters the story is capable of clear and harmonious interpretation by a comparison of its pages with the present condition of things. We know infinitely more of the history of this earth than we do of the history of the sun. Are we then to be told that this knowledge, so patiently accumulated from innumerable observations and so laboriously coordinated and classified, is to be held of none account in comparison with the conclusions of physical science in regard to the history of the central luminary of our system? These conclusions are founded on assumptions which may or may not correspond with the truth. They have already undergone revision, and they may be still further modified as our slender knowledge of the sun, and of the details of its history, is increased by future investigation. In the meantime, we decline to accept them as a final pronouncement of science on the subject. We place over against them the evidence of geology and palæontology, and affirm that unless the deductions we draw from that evidence can be disproved, we are entitled to maintain them as entirely borne out by the testimony of the rocks.

Until, therefore, it can be shown that geologists and palæontologists have misinterpreted their records, they are surely well within their logical rights in claiming as much time for the history of this earth as the vast body of evidence accumulated by them demands. So far as I have been able to form an opinion, one hundred millions of years would suffice for that portion of the history which is registered in the stratified rocks of the crust. But if the palæontologists find such a period too narrow for their requirements, I can see no reason on the geological side why they should not be at liberty to enlarge it as far as they may find to be needful for the evolution of organised existence on the globe. As I have already remarked, it is not the length of time which interests us so much as the determination of the relative chronology of the events which were transacted within that time. As to the general succession of these events, there can be no dispute. We have traced its stages from the bottom of the oldest rocks up to the surface of the present continents and the floor of the present seas. We know that these stages have followed each other in orderly advance, and that geological time, whatever limits may be assigned to it, has sufficed for the passage of the long stately procession.

We may, therefore, well leave the dispute about the age of the earth to the decision of the future. In so doing, however, I should be glad if we could carry away from it something of greater service to science than the consciousness of having striven our best in a barren controversy, wherein concession has all to be on one side and the selection of arguments entirely on the other. During these years of prolonged debate I have often been painfully conscious that in this subject, as in so many others throughout the geological domain, the want of accurate numerical data is a serious hindrance to the progress of our science. Heartily do I acknowledge that much has been done in the way of measurements and experiments for the purpose of providing a foundation for estimates and deductions. But infinitely more remains to be accomplished. The field of investigation is almost boundless, for there is hardly a department of geological dynamics over which it does not extend. The range of experimental geology must be widely enlarged, until every process susceptible of illustration or measurement by artificial means has been investigated. Field-observation needs to be supplemented where possible by instrumental determinations, so as to be made more precise and accurate, and more capable of furnishing trustworthy numerical statistics for practical as well as theoretical deductions.

The subject is too vast for adequate treatment here. But let me illustrate my meaning by selecting a few instances where the adoption of these more rigid methods of inquiry might powerfully assist us in dealing with the rates of geological processes and the value of geological time. Take, for example, the wide range of lines of investigation embraced under the head of Denudation. So voluminous a series of observations has been made in this subject, and so ample is the literature devoted to it, that no department of geology, it might be thought, has been more abundantly and successfully explored. Yet if we look through the pile of memoirs, articles and books,

[1] See an interesting and suggestive paper by Prof. Le Conte on "Critical Periods in the History of the Earth," *Bull. Dept. Geology, University of California*, vol. i. (1895), p. 313; also one by Prof. Chamberlin on "The Ulterior Basis of Time-divisions and the Classification of Geological History," *Journal of Geology*, vol. vi. (1898), p. 449.

we cannot but be struck with the predominant vagueness of their statements, and with the general absence of such numerical data determined by accurate, systematic and prolonged measurement as would alone furnish a satisfactory basis for computations of the rate at which denudation takes place. Some instrumental observations of the greatest value have indeed been made, but, for the most part, observations of this kind have been too meagre and desultory.

A little consideration will show that in all branches of the investigation of denudation opportunities present themselves on every side of testing, by accurate instrumental observation and measurement, the rate at which some of the most universal processes in the geological *régime* of our globe are carried on.

It has long been a commonplace of geology that the amount of the material removed in suspension and solution by rivers furnishes a clue to the rate of denudation of the regions drained by the rivers. But how unequal in value, and generally how insufficient in precision, are the observations on this topic! A few rivers have been more or less systematically examined, some widely varying results have been obtained from the observations, and while enough has been obtained to show the interest and importance of the method of research, no adequate supply of materials has been gathered for the purposes of accurate deduction and generalisation. What we need is a carefully organised series of observations carried out on a uniform plan, over a sufficient number of years, not for one river only, but for all the important rivers of a country, and indeed for all the greater rivers of each continent. We ought to know as accurately as possible the extent of the drainage-area of each river, the relations of river-discharge to rainfall and to other meteorological as well as topographical conditions; the variation in the proportions of mechanical and chemical impurities in the river-water according to geological formations, form of the ground, season of the year and climate. The whole geological *régime* of each river should be thoroughly studied. The admirable report of Messrs. Humphreys and Abbot on the "Physics and Hydraulics of the Mississippi," published in 1861, might well serve as a model for imitation, though these observers necessarily occupied themselves with some questions which are not specially geological and did not enter into others on which, as geologists, we should now gladly have further information.

Again, the action of glaciers has still less been subjected to prolonged and systematic observation. The few data already obtained are so vague that we may be said to be still entirely ignorant of the rate at which glaciers are wearing down their channels and contributing to the denudation of the land.

The whole of this inquiry is eminently suitable for combined research. Each stream or glacier, or each well-marked section of one, might become the special inquiry of a single observer, who would soon develop a paternal interest in his valley and vie with his colleagues of other valleys in the fulness and accuracy of his records.

Nor is our information respecting the operations of the sea much more precise. Even in an island like Great Britain, where the waves and tides effect so much change within the space of a human life-time, the estimates of the rate of advance or retreat of the shore-line are based for the most part on no accurate determinations. It is satisfactory to be able to announce that the Council of this Association has formed a committee for the purpose of obtaining full and accurate information regarding alterations of our coasts, and that with the sanction of the Lords of the Admiralty, the co-operation of the coast-guard throughout the three kingdoms has been secured. We may therefore hope to be eventually in possession of trustworthy statistics on this interesting subject.

The disintegration of the surface of the land by the combined agency of the subaërial forces of decay is a problem which has been much studied, but in regard to whose varying rates of advance not much has been definitely ascertained. The meteorological conditions under which it takes place differ materially according to latitude and climate, and doubtless its progress is equally variable. An obvious and useful source of information in regard to atmospheric denudations is to be found in the decay of the material of buildings of which the time of erection is known, and in dated tombstones. Twenty years ago I called attention to the rate at which marble gives way in such a moist climate as ours, and cited the effects of subaërial waste as these can be measured on the monuments of our graveyards and cemeteries (*Proc. Roy. Soc. Edin.*, vol. x. 1879-80, p. 518). I would urge upon town geologists, and those in the country who have no opportunities of venturing far afield, that they may do good service by careful scrutiny of ancient buildings and monuments. In the churchyards they will find much to occupy and interest them, not, however, like Old Mortality, in repairing the tombstones, but in tracing the ravages of the weather upon them, and in obtaining definite measures of the rate of their decay.

The conditions under which subaërial disintegration is effected in arid climates, and the rate of its advance, are still less known, seeing that most of our information is derived from the chance observations of passing travellers. Yet this branch of the subject is not without importance in relation to the denudation, not only of the existing terrestrial surface, but of the lands of former periods, for there is evidence of more than one arid epoch in geological history. Here, again, a diligent examination of ancient buildings and monuments might afford some, at least, of the required data. In such a country as Egypt, for instance, it might eventually be possible to determine from a large series of observations what has been the average rate of surface-disintegration of the various kinds of stone employed in human constructions that have been freely exposed to the air for several thousand years.

Closely linked with the question of denudation is that of the deposition of the material worn away from the surface of the land. The total amount of sediment laid down must equal the amount of material abstracted, save in so far as the soluble portions of that material are retained in solution in the sea. But we have still much to learn as to the conditions, and especially as to the rate, of sedimentation. Nor does there appear to be much hope of any considerable increase to our knowledge until the subject is taken up in earnest as one demanding and justifying a prolonged series of well-planned and carefully executed observations. We have yet to discover the different rates of deposit, under the varying conditions in which it is carried on in lakes, estuaries, and the sea. What, for instance, would be a fair average for the rate at which the lakes of each country of Europe are now being silted up? If this rate were ascertained, and if the amount of material already deposited in these basins were determined, we should be in possession of data for estimating, not only the probable time when the lakes will disappear, but also the approximate date at which they came into existence.

But it is not merely in regard to epigene changes that further more extended and concerted observation is needed. Even among subterranean movements there are some which might be watched and recorded with far more care and continuity than have ever been attempted. The researches of Prof. George Darwin and others have shown how constant are the tremors, minute but measurable, to which the crust of the earth is subject (*Report Brit. Assoc.*, 1882, p. 95). Do these phenomena indicate displacements of the crust, and, if so, what in the lapse of a century is their cumulative effect on the surface of the land?

More momentous in their consequences are the disturbances which traverse mountain-chains and find their most violent expression in shocks of earthquake. The effects of such shocks have been studied and recorded in many parts of the world, but their cause is still little understood. Are the disturbances due to a continuation of the same operation which at first gave birth to the mountains? Should they be regarded as symptoms of growth or of collapse? Are they accompanied with even the slightest amount of elevation or depression? We cannot tell. But these questions are probably susceptible of some more or less definite answer. It might be possible, for instance, to determine with extreme precision the heights above a given datum of various fixed points along such a chain as the Alps, and by a series of minutely accurate measurements to detect any upward or downward deviation from these heights. It is quite conceivable that throughout the whole historical period some deviation of this kind has been going on, though so slowly, or by such slight increments at each period of renewal, as to escape ordinary observation. We might thus learn whether, after an Alpine earthquake, an appreciable difference of level is anywhere discoverable, whether the Alps as a great mountain-chain are still growing or are now subsiding, and we might be able to ascertain the rate of the movement. Although changes of this nature may have been too slight during human experience to be ordinarily appreciable, their very insignificance seems to me to supply a strong reason why they should be sought for and carefully measured. They would not tell us, indeed, whether a mountain-chain was called into being in one gigantic convulsion,

or was raised at wide intervals by successive uplifts, or was slowly elevated by one prolonged and continuous movement. But they might furnish us with suggestive information as to the rate at which upheaval or depression of the terrestrial crust is now going on.

The vexed questions of the origin of raised beaches and sunk Forests might in like manner be elucidated by well-devised measurements. It is astonishing upon what loose and untrustworthy evidence the elevation or depression of coast-lines has often been asserted. On shores where proofs of a recent change of level are observable it would not be difficult to establish by accurate observation whether any such movements are taking place now, and, if they are, to determine their rate. The old attempts of this kind along the coasts of Scandinavia might be resumed with far more precision and on a much more extended scale. Methods of instrumental research have been vastly improved since the days of Celsius and Linnæus. Mere eye-observations would not supply sufficiently accurate results. When the datum-line has been determined with rigorous accuracy, the minutest changes of level, such as would be wholly inappreciable to the senses, might be detected and recorded. If such a system of watch were maintained along coasts where there is reason to believe that some rise or fall of land is taking place, it would be possible to follow the progress of the movement and to determine its rate.

But I must not dwell longer on examples of the advantages which geology would gain from a far more general and systematic adoption of methods of experiment and measurement in elucidation of the problems of the science. I have referred to a few of those which have a more special bearing on the question of geological time, but it is obvious that the same methods might be extended into almost every branch of geological dynamics. While we gladly and gratefully recognise the large amount of admirable work that has already been done by the adoption of these practical methods, from the time of Hall, the founder of experimental geology, down to our own day, we cannot but feel that our very appreciation of the gain which the science has thus derived increases the desire to see the practice still further multiplied and extended. I am confident that it is in this direction more than in any other that the next great advances of geology are to be anticipated.

While much may be done by individual students, it is less to their single efforts than to the combined investigations of many fellow-workers that I look most hopefully for the accumulation of data towards the determination of the present rate of geological changes. I would therefore commend this subject to the geologists of this and other countries as one in which individual, national and international co-operation might well be enlisted. We already possess an institution which seems well adapted to undertake and control an enterprise of the kind suggested. The International Geological Congress, which brings together our associates from all parts of the globe, would confer a lasting benefit on the science if it could organise a system of combined observation in any single one of the departments of inquiry which I have indicated or in any other which might be selected. We need not at first be too ambitious. The simplest, easiest and least costly series of observations might be chosen for a beginning. The work might be distributed among the different countries represented in the Congress. Each nation would be entirely free in its selection of subjects for investigation, and would have the stimulus of co-operation with other nations in its work. The Congress will hold its triennial gathering next year in Paris, and if such an organisation of research as I have suggested could then be inaugurated a great impetus would thereby be given to geological research, and France, again become the birthplace of another scientific movement, would acquire a fresh claim to the admiration and gratitude of geologists in every part of the globe.

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## SECTION D.

### ZOOLOGY.

OPENING ADDRESS BY ADAM SEDGWICK, M.A., F.R.S., PRESIDENT OF THE SECTION.

*Variation and some Phenomena connected with Reproduction and Sex.*

IN the following Address an attempt is made to treat the facts of variation and heredity without any theoretical preconceptions. The ground covered has already been made familiar to us by the writings of Darwin, Spencer, Galton, Weismann, Romanes and others. I have not thought it advisable to discuss the theories of my predecessors, not from a want of appreciation of their value, but because I was anxious to look at the facts themselves and to submit them to an examination which should be as free as possible from all theoretical bias.

Zoology is the science which deals with animals. Knowledge regarding animals is, for convenience of study, classified into several main branches, amongst the most important of which may be mentioned: (1) the study of structure; (2) the study of the functions of the parts or organs; (3) the arrangement of animals in a system of classification; (4) the past history of animals; (5) the relations of animals to their environment; (6) the distribution of animals on the earth's surface. That part of the science of zoology which deals with the functions of organs, particularly of the organs of the higher animals, is frequently spoken of as physiology, and separated more or less sharply from the rest of zoology under that heading. So strong is the line of cleavage between the work of the physiologist and that of other zoologists, that this Association has thought it advisable to establish a special Section for the discussion of physiological subjects, leaving the rest of zoology to the consideration of the old established Section, D. In calling attention to this fact, I do not for one moment wish to question the advisability of the course of action which the Association has taken. The science of physiology in its modern aspects includes a vast body of facts of great importance and great interest which no doubt require separate treatment. But what I do wish to point out is that it is quite impossible for us here to abrogate all our functions as physiologists Some of the most important problems of the physiological side of zoology still remain within the purview of this Section.

For instance, the important and far-reaching problems connected with reproduction and variation are very largely left to this Section, and that large group of intricate and almost entirely physiological phenomena connected with the adaptations of organisms to their environment are dealt with almost exclusively here. Indeed, we may go further, and say that apart altogether from practical questions of convenience, which make it desirable to separate a part of physiological work from the Zoological Section, it is, as a matter of fact, impossible to divorce the intelligent study of structure from that of function. The two are indissolubly connected together. The differentiation of structure involves the differentiation of function, and the differentiation of function that of structure. The conceptions of structure and function are as closely associated as those of matter and force. A zoologist who confined himself to the study of the structure of organisms, and paid no attention to the functions of the parts, would be as absurd a person as a philologist who studied the structure of words and took no account of their meaning. In the early part of this century, when the subject-matter of zoology was not so vast as it is at present, this aspect of the case was fully recognised, and one of the greatest zoologists of the century, whether considered from the point of view of modern anatomy, or of modern physiology, was Professor of Anatomy and Physiology at the University of Berlin.

Having said that much as to the various aspects of living nature, of natural history, if you like, which it falls within the province of this Section to deal with, I may now proceed to the subject of my address. And when I mention to you what that subject is, you will be able to make some allowance for the somewhat commonplace remarks with which I have treated you. For that subject, though it has its important morphological aspects, is in the main a physiological one; at any rate, no study which does not take account of the physiological aspect of it can ever hope to satisfy the intellect of man. The subject, then, to which I wish to draw your attention at the outset of our proceedings, is the great subject of Variation of Organisms.

As every one knows, there is a vast number of different kinds of organisms. Each kind constitutes a species, and consists of an assemblage of individuals which resemble one another more closely than they do other animals, which transmit their characteristics in reproduction and which habitually live and breed together. But the members of a species, though resembling one another more closely than they resemble the members of other species, are not absolutely alike. They present differences, differences which make themselves apparent

even in members of the same family, *i.e.* in the offspring of the same parents. It is these differences to which we apply the term *variation*. The immense importance of the study of variations may be judged from the fact that, according to the generally received evolution theory of Darwin, it is to them that the whole of the variety of living and extinct organisms is due. Without variation there could have been no progress, no evolution in the structure of organisms. If offspring had always exactly resembled their parents and presented no points of difference, each succeeding generation would have resembled those previously existing, and no change, whether backwards or forwards, could have occurred. This phenomenon of genetic variation forms the bedrock upon which all theories of evolution must rest, and it is only by a study of variations, of their nature and cause, that we can ever hope to obtain any real insight into the actual way in which evolution has taken place. Notwithstanding its importance, the subject is one which has scarcely received from zoologists the attention which it merits.

Though much has been written on the causes of variation, too little attention has of late years been paid to the phenomenon. Since the publication of Darwin's great work on the "Variation of Animals and Plants under Domestication," there have been but few books of first-rate importance dealing with the subject. The most important of these is Mr. William Bateson's work, entitled "Materials for the Study of Variation." I have no hesitation in saying that I regard this work as a most important contribution to the literature of the evolution theory. In it attention is called, with that emphasis which the subject demands, to the supreme importance of the actual study of variation to the evolutionist, and a systematic attempt is made to classify variations as they occur in nature. In preparing this book Mr. Bateson has performed a very real service to zoology, not the least part of which is that he has made a most effective protest against that looseness of speculative reasoning which, since the publication of the "Origin of Species," has marred the pages of so many zoological writers.

The variations of organisms may be grouped under two heads, according to their nature and source: (1) There are those variations which appear to have no relation to the external conditions, for they take place when these remain unchanged, *e.g.* in members of the same litter; they are inherent in the constitution of the individual. These we shall call constitutional variations, or as their appearance seems nearly always to be connected with reproduction, they may be called *genetic* (congenital, blastogenic) *variations*. (2) The second kind of variations are those which are caused by the direct action of external conditions. These variations constitute the so-called *acquired characters*.

My first object is to consider these two kinds of variations, their nature, their causes, and their results on subsequent generations, and to inquire whether there are any fundamental differences between them. In this connection it is of particular importance that we should inquire whether acquired modifications are transmitted in reproduction. As is well known, there are two schools of thought holding directly opposite views as to this matter. The one of these schools—the so-called Lamarckian school—holds that they may be transmitted as such in reproduction; the other school, on the other hand, maintains that acquired modifications affect only the individual concerned, and are not handed on as such in reproduction. That the decision of the matter is not only theoretically important, but also practically, is evident, for upon it depends the answer to the question whether mental or other facilities acquired by the laborious exercise of the individual are ever transmitted to the offspring—whether the facility which the individual acquires in resisting temptation makes it any easier for the offspring to do the same, whether the effects of education are cumulative in successive generations. To put the matter as Francis Galton has put it, Is nature stronger than nurture, or nurture than nature?

We have then two kinds of variation to consider: (1) genetic variation, (2) acquired modification. It is the former of these—namely, genetic variation—with which I wish primarily to deal. Let us examine more fully the mode of its occurrence.

### *Genetic Variation.*

Organised beings present, as you are aware, two main kinds of reproduction, the sexual and the asexual. These two kinds of reproduction present certain differences, of which the most important, and the only one which concerns us now, is the fact that genetic variation is essentially associated with sexual reproduction, and is rarely, if ever, found in asexual reproduction. In other words, whereas the offspring resulting from asexual reproduction as a rule exactly resemble the parent, they are always different from the parents in sexual reproduction. I am aware that I am treading on disputed ground. You will observe that I do not make the assertion that asexually produced offspring *always* exactly resemble the parent, and never present genetic variations. To say that would be going too far in the present state of our knowledge. Therefore I have put the matter less strongly, and merely assert that whereas asexual reproduction is on the whole characterised by identity between the offspring and the parent, sexual reproduction is always characterised by differences more or less marked between the two; and I reserve the question as to whether genetic variations are ever found in asexual reproduction for later consideration.

This modified form of the statement will, I think, be admitted on all hands, but before going on I will illustrate my meaning by reference to actual examples.

Asexual reproduction is a phenomenon comparatively rare in the animal kingdom, and when it does occur it is exceedingly difficult to investigate from this particular point of view. In the vegetable kindom, on the other hand, it is quite common. All, or almost all, plants possess this power, and in a very great many of them the result of its exercise can be fully followed out, and contrasted with that of sexual reproduction. Let us follow it out in the potato-plant. The potato can and does normally propagate itself asexually by means of its underground tubers. As you will know, if you take one of these and plant it, it gives rise to a plant exactly resembling the parent. If the tuber (seed as it is sometimes erroneously called) be that of the Magnum Bonum, it gives rise to a plant with foliage, flowers and tubers of the Magnum Bonum variety; if it be of the Snowdrop, the foliage, flowers, habit and tubers are totally different from the Magnum Bonum, and are easily identified as Snowdrops. In this way a favourable variety of potato can be reproduced to almost any extent with all its peculiarities of earliness or lateness, pastiness or mealiness, power of resisting disease and so forth. By asexual reproduction the exact facsimile of the parent may always be obtained, provided the conditions remain the same.

Now let us turn to the results of sexual reproduction—the seeds, *i.e.* the real seeds, which as you know are produced in the flowers, are the means by which sexual reproduction is effected. They are produced in great quantity by most plants, and when placed in the ground under the proper conditions they germinate and produce plants. But these plants do not resemble the parent. Try the seed of the Magnum Bonum potato, and raise plants from it. Do you think that any of them will be the Magnum Bonum with all its properties of keeping, resisting disease, and so forth? Not a bit of it. The probability is, that not one of your seedling plants will exactly reproduce the parents; they will all be different. Again, take the apple; if you sow the seed of the Blenheim Orange and raise young apple-trees, you will not get a Blenheim Orange. All your plants will be different, and probably not one will give you apples with the peculiar excellence of the parent. If you want to propagate your Blenheim Orange and increase the number of your trees, you must proceed by grafting or by striking cuttings, which are the methods by which such a tree may be asexually reproduced. And so on. Examples might be multiplied indefinitely. Every horticulturist knows that variety characterises seedlings, *i.e.* sexual offspring, whereas identity is found in slips, grafts and offsets, *i.e.* in asexual offspring; and that if you want to get a new plant you must sow seeds, while if you want to increase your stock of an old one you must strike cuttings, plant tubers or proceed in some analogous manner.

An apparent exception to this rule is afforded by so-called bud variation, but it is not certain that this is really an exception. In so far as these bud variations are not of the nature of acquired variations produced by a change of external conditions, and disappearing as soon as the old conditions are renewed, they are probably stages in the growth and development of the organism. That is to say, they are of the same nature as those peculiarities in animals which appear at a particular time of life, such as a single lock of hair of a different colour from the rest of the hair,[1] the change in colour of hair with growth,[2] the appearance of insanity or of epilepsy at a particular age. There

[1] Darwin, "Variation," vol. i. p. 449.

[2] As an example I may refer to the Himalayan rabbit; Darwin, "Variation," vol. i. p. 114.

is nothing more remarkable in a single bud on a tree departing from the usual character at a particular time of life, than in a particular hair of a mammal doing the same thing.

We have seen that, speaking broadly, genetic variation is connected with sexual reproduction, and it becomes necessary to examine this mode of reproduction a little more fully. What is the essence of sexual reproduction, and how does it differ from asexual? What I am now going to say applies generally to the phenomenon whether it occurs in plants or animals. Sexual reproduction is generally carried on by the co-operation of two distinct individuals—these are called the male and female respectively. They produce, by a process of unequal fission which takes place at a part of their body called the reproductive gland, a small living organism called the reproductive cell. The reproductive cell produced by the male is called in animals the spermatozoon, and is different in form from the corresponding cell produced by the female, and called in animals the ovum. The object with which these two organisms are produced is to fuse with one another and give rise to one resultant uninucleated organism or cell, which we may call the *zygote*. This process of fusion between the two kinds of reproductive cells, which are termed *gametes*, is called conjugation. The difference in structure between the male and female gamete is a matter of secondary importance only, and is connected with the primary function of coming into contact and fusing. The same may be said with regard to the so-called sexual differences of the parents of the two kinds of gametes, and to the powerful instincts which regulate their action. The conjugation of the male and female gamete, or the fertilisation of the ovum, as it is sometimes called, consists in the fusion of two distinct masses of protoplasm which are nearly always produced by different individuals. In the case of hermaphrodites, the term applied to organisms which produce both male and female gametes in the same individual, there is generally some arrangement which tends to prevent the male gamete from conjugating with the female gamete of the same parent; but this phenomenon is not absolutely excluded, and takes place as a normal phenomenon in many plants and possibly in some animals.

This fusion of the protoplasm of the two gametes gives us a uninucleated organism—for the fusion of the nuclei of the two gametes seems to be an essential part of the process—in which the potencies of the two gametes are blended. The *zygote*, as the mass formed of the fused gametes is called, is formed by the combination of two individualities, and is therefore essentially a new individuality, the characters of which will be different from the characters of both of the parents. This fact, which is not apparent in the zygote when first established, because the parts are hardly distinguishable by our senses, becomes obvious as soon as organs, with the appearance of which we are familiar, are formed. As a general rule this cannot be said to have occurred until what we call maturity has been nearly reached, because we are not familiar enough with the features of immature organisms to detect individual differences. But you may rest assured that such differences exist at all stages of growth from that of the uninucleated zygote till death. How the characters of the two parents will combine in the zygote it is impossible to predict, and the result is never the same even though the conjugations have been between gametes of identical origin. There may be an almost perfect mixture, the blending extending to even quite minute details; or the characters of the one parent may predominate—be prepotent, as we call it—over those of the other; or they may blend in such a way that the zygote offers characters found in neither parent. Or, finally, the features of one parent may come out at one stage of growth, those of the other at another stage. But, however the characters may blend, the product never exactly resembles the parents. The extent to which it differs from them is the measure of the variation.

To resume, it will be observed that in the method of reproduction sometimes called sexual two distinct processes occur. One of these is the real reproductive act, which consists in the production by fission of uninuclear individuals called gametes; the second is the fusion of the gametes to form the zygote. The gametes are of two kinds, and the reason of there being two kinds is intelligible when we consider the parts they have to play. The male gamete is nearly always endowed with locomotive power, and the female gamete is stored with food material to be used by the zygote in the first stages of growth. The destiny of these two uninucleated organisms is to fuse with one another, and so to give rise to a zygote which ultimately assumes the typical form of the species. As a general rule, the gametes have but a limited duration[1] of life unless they conjugate, and this is quite intelligible when we remember that they have no organs, *e.g.* digestive organs, suitable for the maintenance of life. It is rarely found that they have the power of assuming the form of their parent, unless they conjugate. This never happens in the case of the male gamete (at any rate in animals), and only rarely in that of the female. When it occurs—that is to say, when the ovum develops without conjugation—we call the phenomenon parthenogenesis. Parthenogenesis is found more commonly in Arthropods than in other groups, but it may be more common than is supposed.[2]

In sexual reproduction then, in addition to the real reproductive act, which is the division by fission of the parent into two unequal parts, the one of which continues to be called the parent, while the other is the gamete, there is the subsequent conjugation process. It is to this conjugation process that that important concomitant of sexual reproduction must be attributed, namely, genetic variation. We have thus traced genetic variation to its lair. We have seen that it is due to the formation of a new individuality by the fusion of two distinct individualities. We have also seen that in the higher animals it is always associated with the reproductive act.

Let us now take a wider survey and endeavour to ascertain whether this most important process, a process upon which depends the improvement as well as the degradation of races, ever takes place independently of the reproductive act. In the Metazoa, to which for our present purpose I allude under the term higher animals, conjugation never takes place except in connection with reproduction. It is impossible from the nature of the process that it should do so, as I hope to explain later on. But among the Protozoa, the simplest of all animals, it is conceivable that conjugation might take place apart from reproduction, and as a matter of fact it does do so. Let us now examine a case in which this occurs. Amongst the free-swimming ciliated Infusoria it frequently happens that two individuals become applied together, and that the protoplasm of their bodies becomes continuous. They remain in this condition of fusion for some days, retaining, however, their external form and not undergoing complete fusion. While the continuity lasts there is an exchange of living substance between the two bodies, in which exchange a bit of the nucleus of each participates. It thus happens that at the end of conjugation, when the two animals separate, they are both different from what they were at the commencement; each has received protoplasm and a nucleus from its fellow, and the introduced nucleus fuses as we know with the nucleus which has not moved. It would therefore appear that all the essential features of the conjugation process, as we learnt them in the case of the conjugation of the gametes in the Metazoa, are present, and it is impossible to doubt that we have here an essentially similar phenomenon. The phenomenon differs, however, from the conjugation first described in this interesting and important respect, that the two animals separate and resume their ordinary life. It is true that their constitution must have been profoundly changed, but they retain their general form. I say that the constitution of the exconjugates, as we may call them after they are separated, must be different from what it was before conjugation, but so far as I know no difference in structure corresponding with this difference in constitution has been recorded. I feel no sort of doubt, however, that structural differences, *i.e.* variations, will be detected when the exconjugates are closely scrutinised and compared with the animals before conjugation, and I would suggest that definite observations be made with a view to testing the point. Here, then, we have a case of conjugation entirely dissociated from reproduction. Other cases of a similar character are known among the Protozoa, though as a general rule the fusion between the conjugating organisms is complete and permanent. Among plants conjugation is generally associated with reproduction, but not always, for in certain fungi[3] fusion of hyphæ and consequent intermingling of protoplasm occurs, and is not followed by any

[1] Under favourable conditions, they may live a considerable time—*e.g.* the spermatozoon of certain ants, which are stated by Sir John Lubbock to live in some cases for seven years.

[2] It may be mentioned as a curious fact that parthenogenesis is rarely found in the higher plants, and, as I have said, is not known for the male gamete among animals.

[3] It must be mentioned, however, that in the case of these fungi the fusion of nuclei has not been observed, nor has it been noticed whether the habit, structure, or constitution of the conjugating plants are altered after the fusion.

form of reproduction. Among bacteria alone, so far as I know, has the phenomenon of conjugation never been observed.

To sum up, we have seen that the phenomenon of conjugation is very widely distributed. Excluding the bacteria, there is reason to believe that it forms a part of the vital phenomena of all organisms. Its essential features are a mixture and fusion of the protoplasm of two different organisms, accompanied by a fusion of their nuclei. It results in the formation of a new individuality, which differs from the individualities of both the conjugating organisms. This difference manifests itself in differences in habit, constitution, form, and structure, such differences constituting what we have called genetic variations.

The conjugation of the ovum and spermatozoon in the higher animals, and the corresponding process in the higher plants, are special cases of this conjugation, in which special conjugating individuals are produced, the ordinary individuals being physically incapable of the process. The phenomenon of sex, with all its associated complications, which is so characteristic of the higher animals and plants, is merely a device to ensure the coming together of the two gametes. In the lower animals, it is possible for the ordinary organism to conjugate; consequently the phenomenon does not form the precursor of developmental change, and is in no way associated with reproduction. Indeed, in such cases it is often the opposite of reproduction, inasmuch as it brings about a reduction in the number of individuals, two separate individuals fusing to form one.

### *Acquired Characters.*

We now come to the consideration of the second kind of variations—namely, those which owe their origin to the direct action of external agencies upon the particular organism which shows the variation; or, as Darwin puts it, to the definite action of external conditions. These are the variations which I have called acquired variations or acquired characters. This is not a good name for them, but at the present moment, when I am about to submit them to a critical examination, I do not know of any other which could be suitably applied. Later on, when I sum up the various effects of the direct action of external agencies upon the organism, I may be able to use a more suitable term.

The main peculiarities of acquired variations are two in number; (*a*) they make their appearance as soon as the organism is submitted to the changed conditions; (*b*) speaking generally, they are more or less the same in all the individuals of the species acted upon. As examples of this kind of variations, I may mention the effect of the sun upon the skin of the white man; the Porto Santo rabbit, an individual of which recovered the proper colour of its fur in four years under the English climate;[1] the change of *Artemia salina* to *Artemia milhausenii*; the increase in size of muscles as the result of exercise; and the development of any special facility in the central nervous system. Among plants, variations of this kind are very easily acquired, by altering the soil and climate to which the individuals are submitted. So common are they, that it is quite possible that a large number of species are really based upon characters of this kind; characters which are produced solely by the external conditions, and which frequently disappear when the old conditions are reverted to.

With regard to these variations, we want to ask the following question: Do they ever last after the producing cause of them is removed, and are they transmitted in reproduction? In a great number of cases they either cease when the cause which has produced them is removed, or if they last the life of the individual they are not transmitted in reproduction. But is this always the case? That is the important question we now have to consider.

But before doing so let us inquire what acquired characters really are. The so-called adults of all animals have, as part of their birthright, a certain plasticity in their capacity of reacting to external influences; they all have a certain power of acquiring bodily and mental characters under the influence of appropriate stimuli. This power varies in degree and in quality in different species. In plants, for instance, it is mainly displayed in habit of growth, form of foliage, &c.; in man, in mental acquirements, and so on. But however it is displayed, it is this property of organisms which permits of the acquisition of those modifications of structure which have been so widely discussed as *acquired* characters. Now this power, when closely considered, is in reality only a portion of that capacity for development which all organisms possess, and with which they become endowed at the act of conjugation. A newly formed zygote possesses a certain number of hidden properties which are not able to manifest themselves unless it is submitted to certain external stimuli. It is these stimuli which constitute the external conditions of existence, and the properties of the organism which are only displayed under their influence are what we call acquired characters. They are acquired in response to the external stimuli.

It would appear, then, that every feature which successively appears in an organism in the march from the uninucleated zygote to death is an acquired character. At first the stimuli which are necessary are quite simple, being little more than appropriate heat and moisture; later on they become more complicated, until finally, when the developmental period is over and the mature life begins, the necessary conditions attain their greatest complexity, and their fulfilment constitutes what we call in the higher animals education. Education is nothing more than the response of the nearly mature organism to external stimuli, the penultimate response of the zygote to external stimuli, the ultimate being those of senile decay, which end in natural death. Acquired properties, it will be seen, are really stages in the developmental history. They differ in the complexity of the stimulus required to bring them out. For instance, the segmentation of the egg requires little more than heat and moisture, the walking of the chick the stimulus of light and sound and gravity, the evolutions of an acrobat the same in greater complexity, and, lastly, the action of a statesman requires the stimulation of almost every sense in the greatest complexity. Moreover, not only are there differences in the complexity of the stimulus required, but also in the rapidity with which the organism reacts to it. The chick undergoes its whole embryonic development in three weeks, a man in nine months; the chick develops its walking mechanism in a few minutes, while a man requires twelve months or more to effect the same end. Chickens are much cleverer than human beings in this respect. There is the same kind of difference between them that there is between the power of learning displayed by a Macaulay and that displayed by a stupid child.

An instinct is nothing more than an internal mechanism which is developed with great rapidity in response to an appropriate stimulus. It is difficult for us to understand instincts, because with us almost all developmental processes are extremely slow and gradual. This particularly applies to the development of those nervous mechanisms, the working of which we call reason.

Within certain limits the external conditions may vary without harming the organism, but such variations are generally accompanied by variations in the form in which the properties of the zygote are displayed. If the variations of the conditions are too great, their action upon the organism is injurious, and results in abortions or death. And in no case can the external conditions call out properties with which the zygote was not endowed at the act of conjugation.

It would thus appear that acquired characters are merely phases of development; they are the manifestations of the properties of the zygote, and are called forth only under appropriate stimulation; moreover, they are capable of varying within certain limits, according to the nature of the stimulus, and it is to these variations that the term acquired character has been ordinarily applied.

A genetic character, on the other hand, is the possibility of acquiring a certain feature under the influence of a certain stimulus; it is not the feature itself—that is an acquired character—but it is the possibility of producing the feature. Now as the possibility of producing the feature can only be proved to exist by actually producing it, the term genetic character is frequently applied to the feature itself, which is, as we have seen, an acquired character. In consequence of this fact, that we can only determine genetic characters by examining acquired characters, a certain amount of confusion may easily arise, and has indeed often arisen, in dealing with this subject. This can be avoided by remembering that in describing genetic characters account must always be taken of the conditions. For example, the white fur of the Arctic hare is an acquired character, acquired in response to a certain stimulus; while the power of so responding to the particular stimulus when applied at the correct time is a genetic character. Thus a genetic character is a character which depends upon the nature of the organism,

[1] Darwin, "Variation," ed. 2, vol. i. p. 119.

hile an acquired character depends on the nature of the stimulus.

If we imagine a zygote to be a machine capable of working out certain results on material supplied to it, then we should properly apply the term genetic character to the features of the machinery itself, and the words acquired character to the results achieved by its working. These clearly will depend primarily on the structure of the machinery, and secondarily upon the material and energy supplied to it—that is to say, upon the way in which it is worked.

Variations in genetic characters are variations in the machinery of different zygotes—that is to say, in the constitution—while variations in acquired characters are variations in the results of the working of one zygote according to the conditions under which it is worked.

For instance, let us take the case of those twins which arise by the division of one zygote, and are consequently identical in genetic characters, *i.e.* in constitution. If they are submitted to different conditions, they will develop differences which will depend entirely upon the conditions and the time of life when the differentiation in the conditions occurred. These differences, then, will be a function of the external conditions, *i.e.* of the manner in which the machinery is worked, and constitute what we call variation in acquired characters.

### *Are Acquired Characters Transmissible as such in Reproduction?*

To return to our question, are the so-called acquired characters ever transmitted in reproduction? Let us consider what this question means in the light of the preceding discussion. Acquired characters are features which arise in the zygote in response to external stimuli. Now the zygote at its first establishment has none of the characters which are subsequently acquired. All it has is the power of acquiring them. Clearly, then, acquired characters are not transmitted. The power of producing them is all that can be transmitted; and this power resides in the reproductive organs and in the gametes to which the reproductive organs give rise, so that the question must be put in another form. Is it possible by submitting an organism to a certain set of conditions, and thus causing it to acquire certain characters, so to modify its reproductive organs that the same characters will appear in its offspring as the result of the application of a different and simpler stimulus?

For instance, the power of reading conferred by education, the hardness of the hands and increased size of the muscles produced by manual labour: is it possible that these characters, now produced by complex external stimuli applied at a particular period of life, should ever in future ages be produced by the simpler stimuli found within the uterus, so that a man may be born able to read or write, or with hands horny and hard like those of a navvy?

In trying to find an answer to this question let us first of all look into the probabilities of the case, to see if we can relate the question to any other class of phenomena about which we have, or think we have, definite knowledge.

When an organism is affected by external agents the action may apply to the whole organisation or principally to one organ. Let us take a case in which one organ only appears to be affected, *e.g.* the enlargement by exercise of the right arm of a man. Now, although in this case it is only the muscles of the arm which appear at first sight to be affected, we must not forget that the organs of the body are correlated with one another, and an alteration of one will produce an alteration in others. By exercise of the right arm the muscles of that arm are obviously enlarged, but other changes not so obvious must also have taken place. The bones to which the muscles are attached will be altered; the blood-vessels supplying the muscles will be enlarged, and the nerves which act upon the muscles, and probably the part of the central nervous system from which they proceed, will also be altered. These are some of the more obvious correlated changes which will have occurred; no doubt there will have been others—indeed it is not perhaps too much to say that all the organs of the body will have reacted to the enlargement of the arm—but the effect on organs not in functional correlation with the muscles of the right arm will be imperceptible, and may be neglected. Thus the colour of the hair, the length and character of the alimentary canal, size of the leg muscles, the renal organs, &c., will not show appreciable alteration. Above all, the other arm will not be affected, or if it is affected the alteration will be so slight as not to be noticeable. Now, we know that homologous parts, whether symmetrically homologous or serially so, are in some kind of close connection. For instance, when one member of an homologous series varies, it is commonly found that other members of the same series will also vary. Yet in spite of this connection which exists between the right and left arms and between the right arm and right leg, there is no similar alteration either in the left arm or in the right leg. Now, if parts which from these facts we may suppose to be in some connection are not affected, how can we expect the reproductive organs, not only to be modified, but also to be so modified that the germs which are about to be budded off from them will be so affected as to produce exactly the same character—in this case enlarged muscle, &c.—without the application of the same stimulus, viz. exercise? Thus, while I freely admit that every alteration of an organ in response to external agents will react through the whole organisation, affecting each organ in functional correlation with the affected organ in a way which will depend upon the function of the correlated organ, and possibly other organs not in functional correlation in an indefinite way and to a slight extent, yet I maintain that it is very hard to believe that it will have such a sharp and precise effect upon every spermatozoon and ovum subsequently produced that not merely will these products be altered generally in all their properties, but that one particular part of them—and that part of them always the same—will be so altered that the organisms which develop from them will be able to present the same modification on the application of a different stimulus. It is inconceivable; unless, indeed, we suppose that the very molecules of the incipient organs in the germ are more closely correlated with corresponding parts of the parent body than are the homologous parts of the parent body with one another.

Now, to prove the existence of such a remarkable and intimate correlation would surely require the very strongest and most conclusive evidence. Is there any such strong evidence? I think I may fairly answer this question in the negative. The evidence which has been brought forward in favour of the so-called inheritance of acquired characters is far from conclusive. That such evidence[1] exists I do not deny, but it is all, or almost all, capable of receiving other interpretations.

### *Effect of Changed Conditions upon the Reproductive Organs.*

On the other hand, all the certain evidence we have concerning what happens when the reproductive organs are affected, either directly or by correlation, by a change of conditions—and, as we have seen above, they must be affected if there is to be any change in the offspring—tends to show that there is not any relation between the effect produced on the parent and that appearing in the offspring.

The only means of judging whether the reproductive organs are affected by external conditions is by observing any change which may occur in their function. Now, only two such physiological effects of a change of conditions are certainly known; these are (1) the production of sterility or of partial sterility; (2) the production of an increased but indefinite variability in the offspring. With regard to the first of these effects: One of the most common, or at any rate one of the most noticeable, alterations in an organism, effected by change in the external conditions, is an alteration of the reproductive system, an alterationof such a kind that organisms which had previously freely interbred with one another are no longer able to do so. One of the most common results of removing organisms from their natural surroundings is to induce sterility or partial sterility. There is no reason to doubt that this sterility or tendency to sterility is, broadly speaking, due to an affection of the reproductive system. In the case of the higher animals, it may in some cases be due to an action upon the instincts, but in the lower animals and in plants we can hardly doubt that it is due to a direct action upon the reproductive organs. Indeed in plants these organs are often visibly affected. Among animals, however, there does not appear to be any satisfactory evidence on the point, and it is not known what organs are affected, whether it is the actual gametes, or the reproductive glands, or some of the other organs concerned.[2]

The other result of changed conditions which is certainly known is to induce an increased amount of variability of the genetic kind, though not immediately, often indeed not until

[1] For a good statement and discussion of the evidence in favour of this view, see Romanes' "Darwin and after Darwin," vol. ii. chaps. 3 and 4.

[2] The exact cause of this sterility in the higher animals is a point which specially needs investigation.

after the lapse of some generations. On this point Darwin says: "Universal experience shows us that when new flowers are first introduced into our gardens they do not vary; but ultimately all, with the rarest exceptions, vary to a greater or less extent" ("Variation," 2, p. 249)[1] With regard to the variability thus induced, it is to be noticed that it is not confined to any particular organ, nor does it show itself in any particular way. On the contrary, the whole organisation is affected, and the variations are quite indefinite.

To sum up the argument as it at present stands: (1) a change in conditions cannot affect the next generation unless the reproductive organs are affected; (2) from a consideration of the facts of the case, it is almost inconceivable that the effect produced upon any organ of a given organism by a change of conditions should so modify the reproductive organs of that organism as to lead to a corresponding modification in the offspring without the latter being exposed to the same conditions; (3) the only effects, which are certainly known, of changed conditions upon the reproductive organs are (*a*) the production of sterility; (*b*) an increase in genetic variability.

As far, then, as our certain knowledge goes, it would appear that a change of conditions may have one or both of the following effects:—

(1) A definite change, of the same character, or nearly so, in all the individuals acted upon. Such changes may be adaptive or non-adaptive, but they are not permanent, lasting only so long as the change of conditions, or at most during the life of the individual acted upon. They are not transmitted in reproduction, and do not appear in the offspring unless it is submitted to the same conditions. These variations are the direct result of the action of the environment upon the individual, with the exception of the reproductive organs.

(2) Increase in the variations of the genetic kind These are seen, not in the generation[2] first submitted to the changed condition, but in the next or some subsequent generations. The effect is produced through the reproductive organs. These variations are non-adaptive, and different in each individual.

If the reproductive organs are affected we get an increase in the variations of the genetic kind. These, we have seen, are usually of an indefinite character; they are different in every case, and their nature cannot be predicted from experience. But we still have to ask: Is this is a universal rule? Does it never happen that a change of conditions so affects the reproductive organs as to produce a definite non-adaptive change of the same character or nearly so in all the descendants of the individual acted upon? This is the most obscure question connected with the study of variations. If such changes occur, they might be cumulative, being increased in amount by the continued action of the conditions. They would be non-adaptive, their nature depending on the constitution of the reproductive cells and having no functional relation to the original stimulus.

As possible examples of such variation, I may recall those variations referred to by Darwin as 'fluctuating variations which sooner or later become constant through the nature of the organism and of surrounding conditions, but not through natural selection" ("Origin," ed. 6, p. 176); to the variations in turkeys and ducks which take place as the result of domestication ("Variation," 2, p. 250); to those variations which Darwin had in his mind when he wrote the following sentence ("Origin," p. 72): "There can be little doubt that the tendency to vary in the same manner has often been so strong that all the individuals of the same species have been similarly modified without the aid of selection."

It is, however, as I have said, extremely doubtful if variations of this kind really occur. The appearance of them may be caused by the combination of the two other kinds of variation. In all cases which might be cited in support of their occurrence, there are the following doubtful elements: (1) no clear statement as to whether the variations showed themselves in the individuals first acted upon; (2) no history of the organisms when transported back to the old conditions.

[1] The phenomenon of increased variability following upon change of conditions has most often been observed when the change has been from a state of nature to a state of cultivation. Hence the conclusion has been drawn that the kind of change involved in domestication alone induces variation. But there is no evidence in favour of this view. The evidence shows that change of conditions in itself may induce greater variability.

[2] No doubt the individuals of the generation first submitted to the changed conditions would be affected as regards their reproductive organs, which would be altered in structure, but this has not been made out, though there are indications of such an effect in certain plants, *vide* Appendix.

Moreover, a general consideration of the facts of the case renders it improbable that such similar and definite genetic variations should often occur at any rate in sexual reproduction. For although the effect upon the reproductive organs may possibly be almost the same in nearly all the individuals acted upon, it must not be forgotten that the reproductive elements have to combine in the act of conjugation, and that it is the essence of this act to produce products which differ in every case.

*Effect of Changed Conditions in Asexual Reproduction.*

This brings us to the consideration of the question reserved on p. 503: Are genetic variations ever found in asexual reproduction?

If the views expressed in the earlier part of this address are correct, it would seem to follow that genetic variations are variations in the actual constitution, and are inseparably connected with the act of conjugation. The act of conjugation gives us a new constitution, a new individuality, and it is the characters of this new individual in so far as they differ from the characters of the parents which constitute what we have called genetic variations. According to this, the answer to our question would be that genetic variations cannot occur in asexual reproduction, and that if any indefinite variability recalling genetic variability makes its appearance[1] it must be part of the genetic variability and directly traceable to the zygote from which the asexual generations started.

But if genetic variability is not found in asexual reproduction, the question still remains, Can the other kind of variations—namely, those due to the direct action of external forces upon the organism—be transmitted in asexual reproduction? Now we have already seen that the effect of external agencies acting upon the organism must be regarded under two heads, according as to whether the reproductive organs are or are not affected. If the reproductive organs are not affected, then variations caused by the impact of external forces will not be transmitted; if, on the other hand, they are affected, the next generation will show the effect. We have further seen that in the case of sexual reproduction a modification of the reproductive organs will, because of the intervention of conjugation, appear as an increase in genetic variability only. How will the matter stand in the case of asexual reproduction? First, with regard to modifications which do not affect the reproductive system—they, as in sexual reproduction, will not be transmitted. Secondly, as regards modifications which do affect the reproductive organs—they will be transmitted, *i.e.* they will affect the next generation; and the question arises, How will they be transmitted? For here we have the opportunity wanting in the case of sexual reproduction of studying the transmission of modifications of the reproductive system without the complications introduced by the act of conjugation.

In considering this matter, it must be remembered that the reproductive organs are, with regard to external influences, exactly as any other organ. They can be modified either directly or indirectly, though they are in animals often less liable to direct modification by reason of their internal position.[2] These modifications may, as in the case of other organs, be obvious to the eye of the observer, or they may be so slight as only to be detected by an alteration of function. Now, in the case of the reproductive organs this alteration of function will show itself in the individuals of the next generation (if not before) which proceed directly and without any complication from the affected tissue. How will these individuals be affected? Will they all be affected in the same kind of way or will they they be affected in different ways? Finally, will the modi-

[1] Weismann, "On Heredity," vol. ii. English edition, p. 161. Warren E., "Observation on Heredity in Parthenogenesis," *Proc. Roy. Soc.*, 65, 1899, p. 154. These are the only observations I know of on this subject. They tend to show the presence of a slight variability, but they are not entirely satisfactory. In connection with this matter, I may refer to Weismann's view that *Cypris reptans*, the species upon which his observations were made, reproduces entirely by parthenogenesis, and has lost the power of sexual reproduction. This view is based on the fact that he has bred forty consecutive parthenogenetic generations and has never seen a male. As Weismann bases some important conclusions on this view, with regard to the importance of conjugation in rejuvenescence of organisms, I may point out that the fact that he has bred forty successive generations and has never seen a male cannot be regarded as conclusive evidence that males never appear. We know of many cases in which reproduction can continue for more than forty generations without the intervention of conjugation, *e.g.* ciliated infusoria, many plants, and of other species of crustacea in which the male is very rare and only appears after long intervals.

[2] How far the abnormal position of the testes of mammalia may receive its explanation in this connection is a question worthy of consideration.

fication last their lives only, or will it continue into subsequent asexually produced generations?

Let us endeavour to answer these questions:—

(1) How will the offspring be affected? That will depend entirely upon how the reproductive organ was affected. Will the modification in the offspring have an adaptive relation whatever to the external cause? Now here we have a capital opportunity, an opportunity not afforded at all by sexual reproduction, of examining by experiment and observation the Lamarckian position. My own opinion is that there will be no relation of an adaptive kind between the external cause and the modification of the offspring. For instance, let us imagine, as an experiment, that a number of parthenogenetically reproducing organisms are submitted to a temperature lower than that at which they are accustomed to live. Let us suppose that the cold affects their reproductive organs and produces a modification of the offspring. Will the modification be in the direction of enabling the offspring to flourish in a lower temperature than the parent? My own opinion, as I have said, is that there will probably be no such tendency in the offspring, if all possibility of selection be excluded. But that is only an opinion. The question is unsettled, and must remain unsettled until it is tested upon asexually reproducing organisms.

(2) Will they all be affected in the same kind of way? Yes, presumably they will. I arrive at this conclusion, not by experiment, but by reasoning from analogy. In the case of other organs of the body, the same external cause produces in all individuals acted upon, roughly speaking, the same kind of effect, *e.g.* action of sun upon skin, effect of transplanting maize, Porto Santo rabbits, &c. The question, however, cannot be settled in this way. It requires an experimental answer

(3) Will the modification last beyond the life of the individuals produced by the affected reproductive organ? I can give no answer to this question. We have no data upon which to form a judgment. We cannot say whether it is possible permanently to modify the constitution of an organism in this way, or whether, however strong the cause may be, consistently of course with the non-destruction of life, the effects will gradually die away—it may be in one, it may be in two or more generations. There are cases known which might assist in settling these questions, but I must leave to another opportunity the task of examining them. I refer to such cases as *Artemia salina*, various cases of bud variation which cannot be included under the head of growth variation.

### *Senile Decay and Rejuvenescence of Organisms.*

Another question, also of the utmost importance, confronts us at this point. As is well known, organisms are liable to wear and tear, sooner or later some part or parts essential to the maintenance of the vital functions wear out and are not renewed by the reparative processes which are supposed to be continually taking place in the organism. This constitutes what we call senile decay, and leads to the death of the organism. As a good example of the kind of cause of senile decay, we may mention the wearing out of the teeth, which in mammals at any rate are not replaced; the wearing out of the elastic tissue of the arterial wall, which is probably not replaced. There is no reason to suppose that the reparative process of any organism is sufficiently complete to prevent senile decay. There is probably always some part or parts which cannot be renewed, even in the simplest organisms. Maupas has shown that this holds for the ciliated Infusoria, and he has also shown how the renewal of life, which of course must be effected if the species is to continue, is brought about. He has shown that it is brought about by conjugation, during which process the organism may be said to be put into the melting-pot and reconstituted. For instance, many of the parts of the conjugating individuals are renewed, including the whole nuclear apparatus, which there is every reason to believe is of the greatest importance to living matter.

On reconsidering the life of the Metazoa in light of the facts established by Maupas for the Infusoria, we see that all Metazoa are in a continual state of fission, as are the ciliated Infusoria. They are continually dividing into two unequal parts, one of which we call the parent and the other the gamete. The parent Metazoon must eventually die; it cannot be put into the melting-pot; its parts cannot be completely renovated. The gamete can be put into the melting-pot of conjugation, and give rise to an entirely reconstituted organism, with all the parts and organs brand new and able to last for a certain time, which is the length of life of the individual of the species.

Is there any other way than that of conjugation by which an organism can acquire a complete renewal of its organs? Is the renewal furnished by the development of all the parts afresh which takes place in a parthenogenetic ovum such a complete renewal? This question cannot now be certainly answered, but the balance of evidence is in favour of a negative answer. And this view of the matter is borne out by a consideration of the facts of the case. In all cases of conjugation which have been thoroughly investigated, the nuclear apparatus is completely renewed. It would appear, indeed, as though the real explanation of the uninuclear character of the Metazoon gamete is to be sought in the necessity of getting the nuclear apparatus into the simplest possible form for renewal. Now in the development of a parthenogenetic ovum the ordinary process of renewal of the nucleus is often in partial abeyance. As a rule, it only divides once instead of twice, and there is, of course, no reinforcement by nuclear fusion. It is, of course, possible that the reinforcement by nuclear fusion which occurs in conjugation may have a different explanation from the nuclear reconstitution which takes place in the formation of polar bodies and similar structures. On the other hand, it may all be part of the same process. We cannot tell. So that we are unable to answer the question whether for complete rejuvenescence a new formation of all parts of the organism is sufficient, or whether a reconstitution of the nuclear apparatus of the kind which takes place in the maturation of the Metazoon ovum and the division of the micro-nucleus of Paramœcium is also required; or, finally, whether in addition to the latter phenomenon a reinforcement and reconstitution by fusing with another nucleus is also necessary for that complete rejuvenescence which enables an organism to begin the life cycle again and to pass through it completely.

With regard to buds in plants, there is reason to believe that they share in the growing old of the parent. That is to say, if we suppose the average life of the individual to be 100 years, a bud removed at 50 will be 50 years of age, and only be able to live on the graft for 50 more years.

### *Heredity.*

Having now spoken at some length o. the phenomenon of variation, I must proceed to consider from the same general point of view the phenomenon of heredity.

As we have seen, in asexual reproduction heredity appears, as a general rule, if not always, to be complete. The offspring do not merely present resemblances to the parent—they are identical with it. And this fact does not appear to be astonishing when we consider the real nature of the process. Asexual reproduction consists in the separation off of a portion of the parent, which, like the parent, is endowed with the power of growth. In virtue of this property it will assume, if it does not already possess it, and if the conditions are approximately similar, the exact form of the parent. It is a portion of the parent; it is endowed with the same property of growth; the wonder would be if it assumed any other form than that of the parent. Indeed, it is doubtful if the word heredity would ever have been invented if the only form of increase of organisms was the asexual one, because there being no variation to contrast with it, it would not have struck us as a quality needing a name, any more than we have a name for that property of the number two which causes it to make four when duplicated.

The need for the word heredity only becomes apparent when we consider that other form of reproduction in which the real act of reproduction is associated with the act of conjugation. Looking at reproduction from a broad point of view, we may sum up the difference between the two kinds, the sexual and the asexual, by saying that, whereas the essence of sexual reproduction is the formation of a new individuality, asexual reproduction merely consists in increasing the number of one kind of individual. From this point of view sexual reproduction is better termed the creation of a new individuality, for that, and not the increase in the number of individuals, is its real result. Inasmuch as conjugation of two organisms is the essential feature of sexual reproduction, it would appear that the number of individuals would be actually diminished as a result of it; and this does really happen, though in a masked manner, for we are not in the habit of looking upon the spermatozoon and ovum as individuals, though it is absurd not to do so, as they contain latent all the properties of the species, and are sometimes able to manifest these properties (parthenogenetic ova) without conjugating. In some of the lower organisms the fact that conjugation does not result in an increase of the number of

individuals, but only in the production of a new individuality, is quite apparent, for in them two of the ordinary individuals of the species fuse to form one (many Protozoa).

So that sexual reproduction gives us a new individuality which can spread to almost any extent by asexual reproduction. This asexual reproduction gives us a group of organisms which is quite different from a group of organisms produced by sexual reproduction. Whereas the latter groups constitute what we call species, the former group has, so far as I know, no special name, unless it be variety; but variety is not a satisfactory name, for it has been used in another sense by systematisers.

Heredity, then, is really applicable only to the appearance in a zygote of some of the properties of the gametes. A zygote has this property of one of the precedent gametes, and that property of the other, in virtue of the operation of what we call heredity; it has a third property possessed by neither of the precedent gametes in virtue of the action of variation, the nature of which we have already examined. It is impossible to say which property of a gamete will be inherited, and it is impossible to predict what odd property will result from the combination of the properties of the two gametes. Of one thing only are we certain, that they are never the same in zygotes formed by gametes produced in immediate succession from the same parent.

We may thus regard the activities of the zygote as the resultant of the dashing together of the activities of the gametes.

Conjugation, then, is a process of the utmost importance in biology; it provides the mechanism by which organisms are able to vary, independently of the conditions in which they live. It lies, therefore, at the very root of the evolution problem; the power of combining to form a zygote is one of the fundamental properties of living matter.

*Species.*

Now let us consider one of the effects of this property upon organisms. The effect to which I refer is the division of animals into groups called species. Species are groups of organisms the gametes of which are able to conjugate and produce normal zygotes. Now in nature there appear to be many causes which prevent gametes from conjugating. First and most important of all is some physical incompatibility of the living matter which prevents that harmonious blending of the two gametes which is essential for the formation of a normal zygote. Very little is known as to the real nature of this incompatibility; in fact, it is hardly an exaggeration to say that nothing is known. It may be that there is actual repulsion between the gametes, or it may be, in some cases, at least, that the gametes are able to fuse, but not to undergo that intimate blending which is necesary for the production of a perfect zygote. In some cases we know that something like this happens; for instance, a blend can be obtained between the horse and the ass, but it is not a perfect blend, the product or zygote being imperfect in one most important particular—namely, reproductive power.

A second cause which prevents conjugation is a purely mechanical one—viz. some obstacle which prevents the two gametes from coming together. As an instance of this I may refer to those cases amongst plants in which conjugation is impossible, because the pollen tube is not long enough to reach the ovule. In yet other cases conjugation is impossible because the organisms are isolated from one another either geographically or in consequence of their habits. There are probably many causes which prevent conjugation, but, whatever they may be, the effect of them is to break up organisms into specific groups, the gametes of which do normally conjugate with one another.

In many cases, no doubt, the gametes of organisms which are kept apart in nature by mechanical barriers will conjugate fully if brought together. But in the great majority of cases it is probable no amount of proximity will bring about complete conjugation. There is physical incompatibility. Here is a fruitful opening for investigation. Observations are urgently needed as to the real nature of this incompatibility.

*Importance of the Study of Variation.*

Another and most important effect of conjugation is, as we have seen, the much-spoken-of constitutional or genetic variations. They are, as we have already insisted, of the utmost importance to the evolutionist. Evolution would have been impossible without them, for it is made up of their summation. It becomes, therefore, desirable to find out to what extent a species is capable of varying. This can only be done, as Mr. Bateson has pointed out, by recording all variations found. Mr. Bateson, in his work already referred to, has carried this out, and has shown the way to a collection of these most important data. In order to carry it further, I would suggest that the collection be made, not only for structure, but also for function. This has been done largely for the nervous functions by psychologists and naturalists who pay special attention to the instincts of animals; but we want a similar collection for other functions. For instance, the variations in the phenomena of heat and menstruation, and of rut amongst mammals, and so on. To do this is really only to apply the methods of comparative anatomy and comparative physiology to the members of a species, as they have already been applied to the different species and larger groups of the animal kingdom. Such investigations cannot fail to be of the greatest interest. Indeed, when we have learnt the normal habits and structure of a species, what more interesting study can there be than the study of the possibilities of variation contained within it? Then, when we know the limits of variability of any given specific group, we proceed to try if we can by selective breeding or alteration of the conditions of life alter the variability, and perhaps call into existence a kind of variation quite different in character from that previously obtained as characteristic of the species.

*The Evolution of Heredity and the Origin of Variation.*

These remarks bring me to the consideration of a point to which I am anxious to call your attention, and which is an important aspect of our subject. Has the variability of organisms ever been different from what it is now? Has or has not evolution had its influence upon the property of organisms as it is supposed to have had upon their other properties? There is only one possible answer to this question. Undoubtedly the variability of organisms must have altered with the progress of evolution. It would be absurd to suppose that organisms have remained constant in this respect while they have undergone alteration in all their other properties. If the variability of organisms has altered, it becomes necessary to inquire in what direction has it altered? Has the alteration been one of diminution, or has it been one of increase? Of course, it is possible that there has been no general alteration in extent with the course of evolution, and that the alteration, on the whole, has been one of quality only. But passing over this third possibility, let us consider for the moment which of the two first-named alternatives is likely to have occurred.

According to the Darwinian theory of evolution, one of the most important factors in determining the modification of organisms has been natural selection. Selection acts by preserving certain favourable variations, and allowing others less favourable to be killed off in the struggle for existence. It thus will come about that certain variations will be gradually eliminated. Meanwhile the variations of the selected organisms will themselves be submitted to selection, and certain of these will be in their turn eliminated. In this way a group of organisms becomes more and more closely adapted to its surroundings; and unless new variations make their appearance as the old unfavourable ones are eliminated, the variability of the species will diminish as the result of selection. Is it likely that new variations will appear in the manner suggested? To answer this question we must turn to the results obtained by human agency in the selective breeding of animals. The experience of breeders is that continued selection tends to produce a greater and greater purity of stock, characterised by small variability, so that if the selective breeding is carried too far, variation almost entirely ceases, and there is little opportunity left for the exercise of the breeder's art. When this condition has been arrived at, he is obliged, if he wants to produce any further modifications of his animals, to introduce new blood—*i.e.* to bring in an individual which has either been bred to a different standard, or one in which the variability has not been so completely extinguished.

It would thus appear, and I think we are justified in holding this view, at any rate provisionally, that the result of continued selection will be to diminish the variability of a species; and if carried far enough, to produce a race with so little variability, and so closely adapted to its surroundings, that the

slightest alteration in the conditions of life will cause extinction.[1]

If selection tends to diminish the variability of a species, then it clearly follows that as selection has been by hypothesis the most important means of modifying organisms, variation must have been much greater in past times than it is now. In fact, it must have been progressively greater the farther we go back from the present time.

The argument which I have just laid before you points, if carried to its logical conclusion—and I see no reason why it should not be so carried—to the view that at the first origin of life upon the earth the variability of living matter consequent upon the act of conjugation must have been of enormous range: in other words, it points to the view that heredity was a much less important phenomenon than it is at present. Following out the same train of thought, we are inevitably driven to the conclusion that one of the most important results of the evolutionary change has been the gradual increase and perfection of heredity as a function of organisms and a gradual elimination of variability.

This view, if it can be established, is of the utmost importance to our theoretical conception of evolution, because it enables us to bring our requirements as to time within the limits granted by the physicists. If variation was markedly greater in the early periods of the existence of living matter, it is clear that it would have been possible for evolutionary change to have been effected much more rapidly than at present—especially when we remember that the world was then comparatively unoccupied by organisms, and that with the change of conditions consequent on the cooling and differentiation of the earth's surface, new places suitable for organic life were continually being formed. It will be observed that the conclusion we have now reached, viz. that variation was much greater near the dawn of life than it is now, and heredity a correspondingly less important phenomenon, is a deduction from the selection theory. It becomes, therefore, of some interest to inquire whether a suggestion obtained by a perfectly legitimate mode of reasoning receives any independent confirmation from other sources. The first source of facts to which we turn for such confirmation must obviously be palæontology. But palæontology unfortunately affords us no help. The facts of this science are too meagre to be of any use. Indeed, they are wanting altogether for the period which most immediately concerns us—namely, the period when the existing forms of life were established. This took place in the prefossiliferous period, for in the earliest fossiliferous rocks examples of almost all existing groups of animals are met with.

But although palæontology affords us no assistance, there is one class of facts which, when closely scrutinised, do lend some countenance to the view that when evolutionary change was at its greatest activity, *i.e.* when the existing forms of life were being established, variation was considerably greater than it is at the present day.

But as this address has already exceeded all reasonable limits, and as the question which we are now approaching is one of very great complexity and difficulty, I am reluctantly compelled to defer the full consideration and treatment of it to another occasion. I can only hope that the far-reaching importance of my subject and the interest of it may to some extent atone for the great length which this address has attained.

### APPENDIX.

The following observations on the condition of the male reproductive organs in highly variable plants are quoted from Darwin's "Variation of Animals and Plants under Domestication," vol. ii. p. 256 *et seq.*

In certain plant hybrids which are highly variable, it is known that the anthers contain many irregular pollen-grains. Exactly the same fact has been noticed by Max Wichura in many of our highly cultivated plants which are extremely variable, and which there is no reason to believe have been hybridised, such as the hyacinth, tulip, snapdragon, potato, cauliflower, &c.

[1] The expression extinction of species seems to be used in two senses which are generally confused. Firstly, a species may become modified so that the form with which we are familiar gradually gives place to one or more forms which have been gradually produced by its modification. That is to say, a character or series of characters becomes gradually modified or lost in successive generations. This is not really extinction, but development. Secondly, a species may gradually lose its variability, and become fixed in character. If the conditions then change, it is unable to adapt itself to them, and becomes truly extinct. In this case it leaves no descendants. We have to do with death, and not with development.

The same observer also "finds in certain wild forms the same coincidence between the state of the pollen and a high degree of variability, as in many species of *Rubus*; but in *R. caesius* and *idaeus*, which are not highly variable species, the pollen is sound." A little further on Darwin says "these facts indicate that there is some relation between the state of the reproductive organs and a tendency to variability; but we must not conclude that the relation is strict." Finally he sums up the matter in these words: "On the whole it is probable that any cause affecting the organs of reproduction would likewise affect their product—that is, the offspring thus generated."

## NOTES.

IN his address to the French Association, at the recent Boulogne meeting, Dr. P. Brouardel took as his theme "Hygiene and its Progress during the last 100 Years." He paid special homage to the memory of the great Englishman and Frenchman, Jenner and Pasteur, who had done so much for the promotion of medical science. The first operation in vaccination made in France was performed at Boulogne, June 18, 1800. A public monument—a statue of Jenner—records the event. Referring to some preventive diseases, Dr. Brouardel remarked that in the French army the mortality from typhoid fever is now about 12 in 10,000, and in the present state of the water supply of many towns it is believed that this mortality will not be much reduced. In the German army, however, the mortality from typhoid fever is as low as 1 and 2 per 10,000, owing doubtless to the fact that an order of a Government authority addressed to any municipal body is immediately carried out, so that an impure water supply has soon to be replaced by a better one. But though some French municipalities are indifferent to their responsibilities, others do their duty well, and the mortality from typhoid fever for the whole of France is only 3 per 10,000. Dr. Brouardel referred to several other subjects which came within the range of preventive medicine.

THE application of the Jenner Institute of Preventive Medicine for permission to alter the memorandum of association so as to enable the institute to avail itself of Lord Iveagh's gift of 250,000*l.* was granted by Mr. Justice Cozens Hardy on September 13.

AFTER four months' work on his yacht, Dr. H. C. Sorby, F.R.S., has returned to Sheffield with many hundred specimens of marine animals, preserved by his new methods, so as to show lifelike character and natural colour.

THE Director of the Marine Observatory of San Fernando announces that the Spanish Minister of Finance has given instructions that all instruments intended for observations of the eclipse of the sun on May 27, 1900, are to be admitted free of duty.

SIR WILLIAM PREECE, K.C.B., has recently been making experiments with an electromagnetic system of wireless telegraphy in the Menai Straits. Using a telephone as a receiver, he has succeeded in establishing communication between stations half a mile apart, the messages heard being signals on the Morse code.

WE learn from the *Scientific American* that Prof. J. B. Hatcher, of Princeton University, has just returned from his geological expedition to Patagonia. The primary object of Prof. Hatcher's expedition was to make the most extensive collections possible of fossils of Patagonia. He also devoted considerable attention to gathering ethnological, botanical and zoological specimens. The first Mesozoic mammals ever discovered were found in Patagonia on this expedition, and upward of thirty cases of Mesozoic vertebrates were shipped

north. Naturally Prof. Hatcher gathered much valuable material illustrating the life and customs of the Patagonian Indian tribes, and he has obtained an important series of photographic negatives which depict the geological and physiographic features of that region.

THE *British Central Africa Gazette* (July 24), published at Zomba, announces the arrival at Nyasa of Mr. J. E. S. Moore, who visited Lakes Shirwa, Nyasa, and Tanganyika in 1896 under the auspices of the Royal Society, and has again returned to Central Africa to survey the basin of Lake Tanganyika, to collect specimens of the aquatic fauna and flora, and to study the geological history of this portion of the great Central African rift. Mr. Moore has with him a complete set of apparatus for deep-water dredging, and the results of the present expedition should be even more satisfactory and interesting than those of the previous investigation. On the way to Tanganyika, deep sounding and dredging operations will be made in Lake Nyasa, the Administration gunboat *Guendolen* having been placed at the disposal of the expedition for this purpose. It is intended to spend several months on Lake Tanganyika, and, after leaving the north end of that lake, to proceed to Lakes Kivu, Albert Edward, and Albert, whence it is proposed to make for the East African coast.

WE regret to see the announcement of the death of M. Gaston Tissandier, the founder of our Parisian namesake, *La Nature*, and the author of a number of scientific works. For many years M. Tissandier devoted much attention to ballooning, and made many balloon ascents, during which he obtained information of value to aëronautics and meteorology. The results of his investigations will be found in the *Comptes rendus* of the Paris Academy of Sciences. He was nominated president of the French Association of aërial navigation, and in 1876 received from the Association the Janssen gold medal. His first memoir on the application of electricity to aërial navigation was crowned by the Paris Academy of Sciences. In 1886, M. Tissandier was made a member of the committee on aëronautics by the Minister of War, and also of the civil committee on the same subject by the Minister of the Interior. He was a member of many scientific societies in France, and a vice-president of the French Meteorological Society. He was made a Chevalier of the Legion of Honour in 1872, and in 1893 the Society for the Encouragement of National Industry awarded him the grand gold medal. In addition to his scientific papers, M. Tissandier was the author of several volumes on physics, chemistry, photography, and ballooning.

MR. C. E. STROMEYER has sent us a stereoscopic photograph of what appears to him to have been an induced lightning flash, taken by Mr. S. Jewsbury at Didsbury. The camera by which the photograph was obtained was placed upon the sill of an open window during a thunderstorm, in order to depict any flashes of lightning which might come within its field of view. No flashes were seen in this part of the sky, but when the plate was developed a broken streak of light appeared upon the two pictures. The trail is horizontal and directed towards a lamp-post in a neighbouring road. As similar markings are often found on plates when lighted lamps are in the field, their electrical origin in the present case is difficult to establish; for they may have been produced while the camera was being placed in position, or taken away, with the lens off. Nevertheless the photograph furnishes interesting material for speculation.

MR. T. KINGSMILL sends us two cuttings from the *Shanghai Mercury* referring to two electric displays of an unusual character observed at Shanghai on July 19 and August 10. On the former occasion it is stated:—"The northern sky was in an almost constant blaze of light. Flashes came sometimes from two centres, as though there were an elliptical area of disturbance from whose foci were sent forth the shafts of lightning. At times these flashes would take the opposite course, and starting from the circumference make their way to the foci. Though the lightning flashes reached within twenty-five degrees of the zenith, and were vigorous enough in all conscience, yet nothing but the faintest distant rumbling could be heard." On August 10 "the reflection of lightning was seen from the S.W. and gradually increased in brightness until at about 7.50 it had reached the zenith." The report states that "the lightning played over nearly the whole of the exposed sky, sometimes six and seven streamers at a time lighting up the sky. They were different in appearance from ordinary forked lightning, having rather the appearance of a network of ribbons crossing the exposed sky in all directions, like the discharges in a vacuum tube. The most unusual circumstance was that these discharges, though most vivid, were almost noiseless, and could scarcely be heard above the ordinary jinrickshaw traffic of the street, the only accompanying sound to the brightest display even in the zenith being a low rumbling, as of ordinary very distant thunder." Mr. Kingsmill remarks that both displays were synchronous with distant typhoons.

AT a meeting of the Lincolnshire Naturalists' Union and the Lincolnshire Science Society, on September 11, Dr. G. M. Lowe, the president of both Societies, expressed the hope that something would soon be done to give science—both natural and physical—in Lincolnshire, first, a permanent home, secondly, the means of making useful observations, and thirdly, of recording them. The first requires the establishment of a museum, which would at once be a memorial of the great men who had been born and lived in Lincolnshire, amongst whom may be mentioned Isaac Newton, Sir John Franklin, and Mr. John Cordeaux. As a repository of specimens of the fast disappearing fauna and flora of our former fen country, of specimens of local antiquarian interest, of specimens bearing on the technique of our local arts and manufactures, a museum worthy of Lincolnshire would soon become invaluable. Next month the county authorities will consider an application for space within the Old Keep of the Castle, to erect buildings for an observatory for the reception of astronomical instruments offered to the county, and for a meteorological station. A third requirement is a means of recording and preserving the observations and papers of members of the scientific societies in the county. A magazine devoted to natural and physical science could, Dr. Lowe felt sure, be supported by Lincolnshire alone; and if the writers of observations and of papers on scientific subjects could be persuaded to drop the pedantic, and use as far as possible a simple phraseology, a highly interesting and useful publication could be provided, which would have a stimulating effect in directing the scientific education of the younger generation.

WE have received from Prof. A. Klossovsky a copy of a paper read before the congress of naturalists, &c., at Kieff, entitled, "The Physical Life of our Planet." The author treats the subject on the supposition that the earth is similar to a living organism, in which the various functions and elements are closely connected according to certain laws. He considers that even the variations of terrestrial magnetism depend upon a system of currents which traverse the atmosphere and are in evident correlation with the cyclonic activity of the air, and, further, that the magnetic and electric fields have an influence on the progress of phenomena at the surface of the earth. He gives some interesting accounts of the most recent acquisitions of science in the determination of the different forces which constitute the physics of the globe.

THE U.S. Hydrographic Office has received a sufficient number of reports to enable it to lay down, with substantial accuracy, the track of the destructive West India hurricane referred to in our issue of August 17 (p. 374). It appears to have been first encountered on August 3, in lat. 11° 51′ N., long. 35° 42′ W., further east than any tropical storm hitherto reported to that Office. At noon (Greenwich time) on the 7th, observations of barometers and winds between St. Kitts and Barbados showed unmistakably the presence of a hurricane to the eastward. The centre of the storm reached Porto Rico on the 8th, Haiti on the 9th, Bahamas on the 12th, and Jupiter, on the Florida coast, on the 13th, and then continued its path parallel to the general trend of the U.S. coast, where vessels continued to report gales of hurricane force until the 19th. The lowest barometer reading, 28·35 inches, appears to have occurred off the Florida coast on August 14. When the hurricane was last reported, in the afternoon of the 21st, it was near lat. 40° N. and long. 60° W., much weakened in energy. The life of the storm is longer than any hitherto reported to the Hydrographic Office.

THE thirty-sixth annual report of the Government Cinchona Plantation in Sikkim, by Surgeon-Major D. Prain, shows that the issues of quinine during the year 1897–98 amounted to 10,939 lbs., as against 8482 lbs. in 1896–97. The medical depôts required 1710 lbs. more than during the preceding year, and the sales to Government officers for distribution in their districts exceeded those of 1896–97 by 1086 lbs. As Sir George King feared, there has been a very marked decline in the demand for quinine for division into pice-packets for sale at Post-offices. The falling off in the demand, so far as Bengal is concerned, may be due to some special cause not active elsewhere; at all events, 800 lbs. have been asked for and supplied during the year for conversion into pice-packets in the North-western Provinces.

DURING the year 1898–99 covered by the report of the Royal Botanic Garden, Calcutta, especial attention was given to the cultivation and distribution of plants of economic value. In connection with the question of rubber and gutta-percha, it has been ascertained, after examination of the milky juice of species of Sideroxylon belonging to the natural family Sapotaceæ, that, though these species do not yield a true rubber, the material obtained from them might prove capable of being utilised for the various purposes for which gutta-percha or india-rubber is now employed. An interesting introduction to India during the year was *Polygala butyracea*, an African species, which yields an excellent vegetable oil. The cultivation and the identification of living plants yielding Indian products of hitherto doubtful origin were continued during the year with good results.

WE have received two papers on earthquakes registered at the observatory of Catania during the present year (*Boll. dell' Accad. Gioenia di Sci. Nat. in Catania*, 1899). Prof. Riccò describes the records of an earthquake in the Peloponnesus on January 22 made by the great seismometrograph, which is 25·3 m. long and has a mass of 300 kg., and by the Brassart seismometrograph. Mr. Arcidiacono gives an account of three diagrams obtained by the former instrument between 7 and 10 p.m. (G.M.T.) on May 3, the first being evidently made by a distant earthquake, which proved to be a strong shock in the Peloponnesus; and the other two by local shocks originating below the south-west flank of Etna at the same spot as the destructive earthquake of May 14, 1898. The author suggests that the Sicilian focus was in a critical condition, and that the two movements there were precipitated by the earlier disturbance in Greece.

THE Free Museum of Science and Art of the University of Pennsylvania issues an illustrated *Bulletin*, in the last number of which (vol. ii. No. 2) an account is given of the new museum buildings in which will be lodged the fine collections of Drs. W. H. Furness and H. M. Hiller and Mr. A. C. Harrison, jun., from Borneo and adjacent islands; the collection from Sarawak is second only to that in the Sarawak Museum at Kuching, and in some respects probably surpasses it. The *Bulletin* contains a report on the recent excavations of the University at Nippur, an account of the Rittenhouse Orrery, and a catalogue of the recent additions to the Museum, some of the more interesting specimens being figured.

THE Dorset County Council has set a good example in arranging for a series of reports with analyses of the soils of the county. The work has been carried out in Reading College under the superintendence of Mr. Douglas A. Gilchrist, and the soils have been analysed by Mr. C. M. Luxmoore and Mr. A. M. Ryley. The first annual report has just reached us; it forms Supplement No. viii. to the *Journal* of Reading College, August 1899. Soils have been taken from areas where different geological formations are developed from the Lower Lias of the Vale of Marshwood to the Reading Beds near Wimborne; a few analyses are also given of soils from Berkshire, Hampshire, and Oxfordshire. The results so far obtained are full of interest, and are likely to prove of great practical importance. Suggestions are made for the manuring of the principal farm crops on the different classes of soils, as well as on the suitability of the soils for particular crops.

AN excellent "Sketch of the Geology of the Lower Carboniferous Rocks of Derbyshire" has been contributed by Mr. H. H. Arnold Bemrose to the August number of the *Proceedings* of the Geologists' Association. The Mountain Limestone with its caverns and lead mines, the Yoredale Rocks and the Millstone Grit are duly described, and the leading fossils are noted. Mention is made of Dr. Wheelton Hind's opinion that the Yoredale Rocks of Derbyshire are newer than those of the typical district in Wensleydale. Further research on this subject is needed. References are made to the Glacial Drift, the Pleistocene Mammalia, the Warm Springs, and other subjects. A more particular account is given of the igneous rocks generally known as Toadstones, and of the occurrence of volcanic vents, as well as tuffs, lavas and sills. There are notes also on marmorised, dolomitised and silicified limestones. The article is well illustrated with maps, sections, and pictorial views.

MANY persons are under the impression that shore-nesting birds make no nest, but lay their eggs indiscriminately among the shingle. This Mr. Patten, in the September number of the *Irish Naturalist*, shows to be a complete misconception so far as the Little Tern is concerned. As a matter of fact, the bird excavates a conical pit in the sand about two inches deep. Immediately round the "crater" a narrow zone of sand is cleared from shingle; and when completed and containing its full clutch of two or three eggs, the deepest part of the nest is filled with broken shells, into which the eggs are wedged with their points downwards. As the eggs are disproportionately large in relation to the bird, it is manifest that the position in which they are placed renders them most easily covered by the brooding hen. It has been assumed that the "crater" is excavated by the hen-bird "breasting" the sand in the manner that sparrows dust themselves by the road-side, but the author is of opinion that the work is done with the beak.

THE discussion in regard to the Ground-sloth whose skin and other remains have been found in a cave in Patagonia has assumed a new phase. It will be remembered that in a recent

contribution to our columns Dr. Moreno stated his belief that the animal belonged to the genus *Glossotherium* (= *Grypotherium*), the creation of a new genus (*Neomylodon*) for its reception being accordingly superfluous. Accepting this determination, but using the synonym *Grypotherium*, Dr. R. Hauthal, in a paper recently communicated to the "Revista del Museo de la Plata" (vol. ix. p. 409), comes to the conclusion that the animal in question was kept by the prehistoric Indians of Patagonia in a domesticated state, and that the cave at Ultima Esperanza was the stable where the herd was nightly collected! Several specimens of the hide, as well as abundant droppings in a dried state, have been obtained; but in spite of this, the author is of opinion that all the remains date from prehistoric times. And he gives reasons for the belief that the creature cannot be living at the present day. Considering the animal in question to be distinct from the typical species, the author and his colleague Mr. Roth bestow the new title *G. domesticum*, apparently oblivious of Dr. Ameghino's earlier name *listai*. The promised continuation of this remarkable paper will be awaited with interest.

SOME very interesting features in development are brought to light in Mr. J. S. Budgett's "Notes on Batrachians of the Paraguayan Chaco," published in the last issue of the *Quarterly Journal of Microscopical Science*. It is well known that in some of the arboreal frogs the tadpole stage, to meet the necessities of existence, is more or less abbreviated; and the author describes an instance of this in a species of *Phyllomedusa*, illustrating his notes with a beautiful coloured plate. After mentioning how the male and female hold together the edges of a leaf (which afterwards become united by the jelly of the egg-mass) during oviposition so as to form a funnel for the reception of the eggs, the developmental stages are described in detail. In the short period of six days the embryo leaves the egg as a pellucid tadpole of a bright green colour, whose only conspicuous parts are its eyes. The tadpole, which may have to travel several inches in order to reach the water, is hatched without a trace of yolk, and with the loss of external gills; breathing taking place by means of a median spiracle, and the lungs being distinctly visible through the body-wall. Pigment is locally developed next day; and at the end of about five weeks the hind limbs appear. When both pairs of limbs are developed, the young frog lands, and sits quietly among the grass till its tail is completely absorbed, when it is practically adult.

THE second volume of Prof. G. O. Sars' work on the Crustacea of Norway, dealing with the Isopoda, has just been completed. The volume is the first in which the Scandinavian Isopoda are treated as a whole, and it should be of much practical use to zoologists. The third volume of the work, now in preparation, will treat of the anomalous group Cumacea, and will consist of about 150 pages with sixty plates.

AT the Royal Victoria Hall, Waterloo Bridge Road, the following popular science lectures will be delivered on Tuesday evenings during October:—October 3, "The Value of Nitrogen," Prof. Holland Crompton, F.R.S. October 10, "Liquid Air," Prof. W. Ramsay, F.R.S. October 17, "Source and Course of the River Thames," Dr. C. G. Cullis. October 24, "Photographs taken in the Dark," Dr. Russell, F.R.S. October 31, "Kamchatka," Captain Barrett Hamilton.

THE additions to the Zoological Society's Gardens during the past week include a Maholi Galago (*Galago maholi*) from South Africa, presented by Mr. James W. Park; two Black-eared Marmosets (*Hapale penicillata*) from South-east Brazil, presented by Mr. F. M. Still; a Guinea Baboon (*Cynocephalus sphinx*, ♀) from West Africa, presented by Mr. J. Huxley; a Black-backed Jackal (*Canis mesomelas*), four Bristly Ground Squirrels (*Xerus setosus*), a Vulturine Eagle (*Aquila verreauxi*, juv.), two Hispid Lizards (*Agama hispida*), four Delalande's Lizards (*Nucras delalandii*), seven Rufescent Snakes (*Leptodira hotambaeia*), four Crossed Snakes (*Psammophis crucifer*), five Rhomb-marked Snakes (*Trimerorhinus rhombeatus*), eight Rough-keeled Snakes (*Dasypeltis scabra*), an Infernal Snake (*Boodon infernalis*), two Puff Adders (*Bitis arietans*) from South Africa, presented by Mr. J. E. Matcham; a Fulmar (*Fulmarus glacialis*) from Iceland, presented by Mr. G. S. Hett; a Lapwing (*Vanellus cristatus*), British, presented by the Rev. A. Barham Hutton; a Herring Gull (*Larus argentatus*), British, presented by Mr. J. L. Bell; two Common Chameleons *Chamaeleon vulgaris*) from North Africa, presented by Mr. Ronald H. Archer; a Common Viper (*Vipera berus*), British, presented by Mr. P. Debell Tuckett; a Kinkajou (*Cercoleptes caudivolvulus*) from South America, an Arctic Fox (*Canis lagopus*) from Finland, a Palm Squirrel (*Sciurus palmarum*, albino) from India, a Black-headed Conure (*Conurus nanday*) from Paraguay, deposited.

## *OUR ASTRONOMICAL COLUMN.*

HOLMES' COMET 1899 *d* (1892 III.).—

*Ephemeris for 12h. Greenwich Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ ″ | Br. $r^{-2}$ | Br. $(r\Delta)^{-2}$ |
|---|---|---|---|---|
| Sept. 21 | 3 9 35 98 | +44 45 19·7 | 0·1758 | 0·05727 |
| 22 | 9 31·29 | 44 57 20·3 | | |
| 23 | 9 24·28 | 45 9 10 2 | | |
| 24 | 9 14·91 | 45 20 49·1 | | |
| 25 | 9 3 18 | 45 32 16·4 | 0·1740 | 0·05809 |
| 26 | 8 49·09 | 45 43 31·8 | | |
| 27 | 8 32·62 | 45 54 34·8 | | |
| 28 | 8 13·75 | 46 5 25·0 | | |
| 29 | 7 52·50 | 46 16 2·0 | 0·1721 | 0·05881 |
| 30 | 7 28·86 | 46 26 25·1 | | |
| Oct. 1 | 7 2·85 | 46 36 34·1 | | |
| 2 | 6 34·46 | 46 46 28 2 | | |
| 3 | 3 6 3·71 | +46 56 7·2 | 0·1702 | 0·05939 |

NEW SPECTROSCOPIC MULTIPLE STAR.—The San Francisco correspondent of the *Standard* (September 11) reports that Prof. W. W. Campbell, of the Lick Observatory, announces that he has obtained spectroscopic evidence that the North Pole star, Polaris, is in reality a system consisting of three bodies. Two of these revolve round each other in a period of *four* days, and simultaneously they together revolve around a third body, in the same manner as the earth and planets revolve round the sun. It is improbable that any of these distant bodies will ever be visible separately, their distance from each other being so small that it can only be detected by the change in wave-length of the lines in the spectrum of the system, owing to the continual approach and recession of each component during their mutual revolutions.

SOUTHERN VARIABLE STARS.—In the *Astronomical Journal* (No. 468), Mr. R. T. A. Innes gives the results of observations on variable stars made at the Cape Observatory since 1896. The working catalogue was mainly derived from lists supplied by Prof. J. C. Kapteyn, who noted all suspected cases of variability in the course of his work on the *Cape Photographic Durchmusterung*. The present communication considers twenty-seven stars, of which one is probably of the Algol type. The period of this is found to be 12·906 days, and consequently this star is conspicuous as being the longest period Algol variable. Its position is

$$\left.\begin{array}{l}\text{R.A. 7h. 42m. 41·1s.}\\ \text{Decl.} - 41^\circ\ 4'\cdot 0\end{array}\right\}(1875);$$

The visual variation of magnitude is from 9·5 to 10·7, and photographically from 9·3 to 10·2.

THE *Bulletin de la Société Astr. de France* for September contains several interesting papers.—"Photography of stellar spectra," by Prof. A. Cornu, consists of a short description of the methods and results of researches into stellar constitution. MM. Flammarion and Antoniadi describe their most recent observations of Mars, including illustrations showing the land-

markings and the variations of the polar cap with the seasons.—M. Em. Touchet contributes an illustrated account of his successful attempt to photograph the "shadow cast by the planet Venus." This he did on January 11, with an exposure of fifteen minutes, the object casting the shadow being an incandescent bulb-holder placed about 21 cm. from the plate.—Lastly, rather more than nine pages are devoted to a dissertation, by M. Rideau, on "the satellites of Jupiter," dealing with their dimensions, surface, probable variability of brightness, eclipse and other phenomena.

## *SOLID HYDROGEN.*[1]

IN the autumn of 1898, after the production of liquid hydrogen was possible on a scale of one or two hundred c.c., its solidification was attempted under reduced pressure. At this time, to make the isolation of the hydrogen as effective as possible, the hydrogen was placed in a small vacuum test-tube, placed in a larger vessel of the same kind. Excess of the hydrogen partly filled the circular space between the two vacuum vessels. The apparatus is shown in Fig 1. In this way the evaporation was mainly thrown on the liquid hydrogen in the annular space between the tubes. In this arrangement the outside surface of the smaller tube was kept at the same temperature as the inside, so that the liquid hydrogen for the time was effectually guarded from influx of heat. With such a combination the liquid hydrogen was evaporated under some 10 mm. pressure, yet no solidification took place. Seeing experiments of this kind required a large supply of the liquid, other problems were attacked, and any attempts in the direction

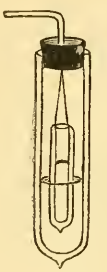

FIG 1.

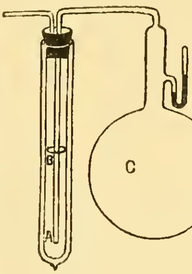


FIG 2.

of producing the solid for the time abandoned. During the course of the present year many varieties of electric resistance thermometers have been under observation, and with some of these the reduction of temperature brought about by exhaustion was investigated. Thermometers constructed of platinum and platinum-rhodium (alloy) were only lowered $1\frac{1}{2}°$ C. by exhaustion of the liquid hydrogen, and they all gave a boiling point of $-245°$ C., whereas the reduction in temperature by evaporation *in vacuo* ought to be $5°$ C., and the true boiling point from $-252°$ to $-253°$ C. In the course of these experiments it was noted that almost invariably there was a slight leak of air, which became apparent by its being frozen into an air snow in the interior of the vessel, where it met the cold vapour of hydrogen coming off. When conducting wires covered with silk have to pass through india-rubber corks it is very difficult at these excessively low temperatures to prevent leaks, when corks get as hard as a stone, and cements crack in all directions. The effect of this slight air leak on the liquid hydrogen when the pressure got reduced below 60 mm. was very remarkable, as it suddenly solidified into a white froth-like mass like frozen foam. My first impressions were that this body was a sponge of solid air containing the liquid hydrogen, just like ordinary air, which is a magma of solid nitrogen containing liquid oxygen. The fact, however, that this white solid froth evaporated completely at the low pressure without leaving any substantial amount of solid air led to the conclusion that the body after all must be solid hydrogen. This surmise was confirmed by observing that if the pressure, and therefore the temperature, of the hydrogen was allowed to rise, the solid melted when the pressure reached about 55 mm. The failure of the early experiment must then have been due to supercooling of the liquid, which is prevented in this case by contact with metallic wires and traces of solid air. To settle the matter definitely, the following experiment was arranged. A flask, C, of about a litre capacity, to which a long glass tube bent twice at right angles was sealed, as shown in Fig. 2, and to which a small mercury manometer can be sealed, was filled with pure dry hydrogen and sealed off. The lower portion, A B, of this tube was calibrated. It was surrounded with liquid hydrogen placed in a vacuum vessel arranged for exhaustion. As soon as the pressure got well reduced below that of the atmosphere, perfectly clear liquid hydrogen began to collect in the tube A B, and could be observed accumulating until, about 30 to 40 mm. pressure, the liquid hydrogen surrounding the outside of the tube suddenly passed into a solid white foam-like mass, almost filling the whole space. As it was not possible to see the condition of the hydrogen in the interior of the tube A B when it was covered with a large quantity of this solid, the whole apparatus was turned upside down in order to see whether any liquid would run down A B into the flask C. Liquid did not flow down the tube, so the liquid hydrogen with which the tube was partly filled must have solidified. By placing a strong light on the side of the vacuum test-tube opposite the eye, and maintaining the exhaustion to about 25 mm., gradually the solid became less opaque, and the material in A B was seen to be a transparent ice in the lower part, but the surface looked frothy. This fact prevented the solid density from being determined, but the maximum fluid density has been approximately ascertained. This was found to be 0·086, the liquid at its boiling point having the density 0·07. The solid hydrogen melts when the pressure of the saturated vapour reaches about 55 mm. In order to determine the temperature, two constant volume hydrogen thermometers were used. One at $0°$ C. contained hydrogen under a pressure of 269·8 mm., and the other under a pressure of 127 mm. The mean temperature of the solid was found to be $16°$ absolute under a pressure of 35 mm. All the attempts made to get an accurate electric resistance thermometer for such low temperature observations have been so far unsatisfactory. Now that pure helium is definitely proved to be more volatile than hydrogen, this body, after passing through a spiral glass tube immersed in liquid hydrogen to separate all other gases, must be compared with the hydrogen thermometer. For the present the boiling point which is $21°$ absolute at 760 mm., compared with the boiling point at 35 mm., or $16°$ absolute, enables the following approximate formula for the vapour tension of liquid hydrogen below one atmosphere pressure to be derived :—

$$\log p - 6{\cdot}7341 - 83{\cdot}28/T \text{ mm.},$$

where $T$ = absolute temperature, and the pressure is in mm. This formula gives us for 55 mm. a temperature of $16{\cdot}7°$ absolute. The melting point of hydrogen must therefore be about $16°$ or $17°$ absolute. It has to be noted that the pressure in the constant volume hydrogen thermometer, used to determine the temperature of solid hydrogen boiling under 35 mm., had been so far reduced that the measurements were made under from one-half to one-fourth the saturation pressure for the temperature. When the same thermometers were used to determine the boiling point of hydrogen at atmospheric pressure, the internal gas pressure was only reduced to one-thirteenth the saturation pressure for the temperatures. The absolute accuracy of the boiling points under diminished pressure must be examined in some future paper. The practical limit of temperature we can command by the evaporation of solid hydrogen is from $14°$ to $15°$ absolute. In passing it may be noted that the critical temperature of hydrogen being $30°$ to $32°$ absolute, the melting point is about half the critical temperature. The melting point of nitrogen is also about half its critical temperature. The foam-like appearance of the solid when produced in an ordinary vacuum is due to the small density of the liquid, and the fact that rapid ebullition is substantially taking place in the whole mass of liquid. The last doubt as to the possibility of solid hydrogen having a metallic character has been removed, and for the future hydrogen must be classed among the non-metallic elements.

[1] Read before the British Association (Section B), Dover Meeting, by Prof. James Dewar, F.R.S.

## AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

AS already notified, the forty-eighth meeting of the American Association for the Advancement of Science was held at Columbus, Ohio, on August 19–26. Dr. W. O. Thompson, President of the Ohio State University, welcomed the Association on behalf of the University, and Dr. Edward Orton, the President, in expressing the thanks of the Association, briefly referred to some of the scientific advances of the present century.

The address of Prof. F. W. Putnam, the retiring President of the Association, was printed in NATURE of September 7, and the following are extracts from some of the addresses delivered by the Presidents of the Sections.

### THE FUNDAMENTAL PRINCIPLES OF ALGEBRA.

In his address to the Section of Mathematics and Astronomy, Prof. Alexander Macfarlane reviewed historically and critically the several advances which have been made in the present century respecting the fundamental principles of algebra. The conclusion reached, after a statement and criticism of algebraic symbols, operations and laws, is as follows:—

If the elements of a sum or a product are independent of order, then the written order of the terms is indifferent, and the product of two such sums is the sum of the partial products; but when the elements of a sum or of a product have a real order, then the written order of the elements must be preserved, though the manner of their association may be indifferent, and a power of a binomial is then different from a product. This applies whether the sum or product occurs simply, or as the index of a base.

Descartes wedded algebra to geometry; formalism tends to divorce them. The progress of mathematics within the century has been from formalism towards realism; and in the coming century, it may be predicted, symbolism will more and more give place to notation, conventions to principles, and loose extensions to rigorous generalisations.

### THE FIELD OF EXPERIMENTAL RESEARCH.

Prof. Elihu Thomson described to the Section of Physics a few of the recent developments of physical science, and pointed out that physical research by experimental methods is both a broadening and a narrowing field. There are many gaps yet to be filled, data to be accumulated, measurements to be made with great precision, but the limits within which experimental work can be done are becoming, at the same time, more and more defined. In most fields of research progress in the future will depend in an increasing degree upon the possession, by the investigator, of an appreciation of small details and magnitudes, together with a refined skill in manipulation or construction of apparatus. He must be ready to guide the trained mechanic, and be able himself to administer those finishing touches which often mark the difference between success and failure.

In conclusion, Prof. Thomson remarked that his endeavours had been to indicate in his address directions in which the field of experiment may be extended, and to emphasise the fact that research must be carried on by extension of limits, necessitating more liberal endowment of research laboratories. The physicist must avail himself of the powers and energies set in play in the larger industrial enterprises, and finally the field of possible exploration in physics by experimental methods has its natural boundaries, outside of which our advances in knowledge must be derived from a study of celestial bodies.

The riddle of gravitation is yet to be solved. This all-permeating force must be connected with other forces and other properties of matter. It will be a delicate task, indeed, for the total attraction between very large masses closely adjacent, aside from the earth's attraction, is very small.

Scientific facts are of little value in themselves. Their significance is their bearing upon other facts, enabling us to generalise and so to discover principles, just as the accurate measurement of the position of a star may be without value in itself, but in relation to other similar measurements of other stars may become the means of discovering their proper motions. We refine our instruments; we render more trustworthy our means of observation; we extend our range of experimental inquiry, and thus lay the foundation for the future work, with the full knowledge that, although our researches cannot extend beyond certain limits, the field itself is, even within those limits, inexhaustible.

### THE DEFINITION OF THE ELEMENT.

Prof. F. P. Venable briefly discussed the nature of the elements in his address to the Section of Chemistry. He passed in review some of the evidence which leads to the belief that the so-called elementary atoms are but compounds of an intimate peculiar nature, the dissociation of which has not yet been accomplished. Referring to the conclusions to which investigations lead, it was remarked that the hypothesis that the elements are built up of two or more common constituents has a larger number of supporters, and would seem more plausible than Graham's hypothesis. Some have supposed one such primal element by the condensation or polymerisation of which the others were formed. Others have adopted the supposition of two elements.

There are many practical difficulties in the way of these suppositions; the lack of uniformity in the differences between the atomic weights, the sudden change of electro-chemical character, and the impossibility, so far, of discovering any law underlying the gradation in the properties of the elements with the increase of atomic weights, are some of the difficulties. In comparing these two hypotheses, that of Graham seems very improbable. It is possible to think of valency as dependent upon the character of the motion of the atom, but one cannot well conceive of a similar dependence of atomic weight and all the other properties. There remains, then, the hypothesis of primal elements by the combination of which our elements have been formed. These molecules are probably distinguished from the ordinary molecules by the actual contact and absolute union of the component atoms without the intervention of ether.

Since these elemental molecules cannot as yet be divided, the name atom may be retained for them, but the idea of simplicity and homogeneity no longer belongs to them. The definition of an element as a body made up of similar atoms is equally lacking in fidelity to latest thought and belief, but chemists would scarcely consent to change it, and, indeed, it may well be retained, provided the modified meaning is given to the word atom. But, after all, an element is best defined by means of its properties. It is by close study of these that its elemental nature is decided, and through them it is tested. Complete reliance can no longer be placed upon the balance and the supposed atomic weight.

### THE DEVONIAN SYSTEM OF CANADA.

Mr. J. F. Whiteaves's address to the Section of Geology and Geography was upon the present state of knowledge of the Devonian rocks of Canada, from a palæontologist's point of view. In accordance with long usage in Canada, the line of demarcation between the Silurian and Devonian systems was drawn at the base of the Oriskany sandstone. The information that has so far been gained about the Devonian rocks of Canada was considered in geographical order, from east to west, under the three following heads, viz. (1) The Maritime Provinces and Quebec; (2) Ontario and Keewatin; and (3) Manitoba and the North-west Territories.

The present state of our knowledge of the Devonian rocks of the whole Dominion, from a purely palæontological standpoint, was thus briefly summarised:—We now possess a fairly satisfactory knowledge of the fossils of the Devonian rocks of Ontario, and of the relations which these rocks bear to the typical section in the State of New York. The fossil plants of the Gaspé sandstones have been described and figured by Sir William Dawson, and the remarkable assemblages of fossil fishes from the Upper Devonian of Scaumenac Bay and Lower Devonian near Campbellton have been worked out somewhat exhaustively, the earlier collections in Canada, and the later ones by the best ichthyological authorities in London and Edinburgh. We have now some idea of the fossil fauna of the Manitoba Devonian, and have added materially to our knowledge of the fossils of the Devonian rocks of the Athabasca and Mackenzie River districts. But, on the other hand, our knowledge of the organic remains of the Devonian of Nova Scotia is still in its infancy, and it would seem that the plant-bearing beds near St. John, N.B., which have so long been regarded as Devonian, may possibly be Carboniferous. In the Rocky Mountain region of Alberta we have not always succeeded in distinguishing Devonian rocks from Carboniferous, and we have yet to obtain a much fuller knowledge than we now possess of the Devonian fossils of Keewatin and the area to the south-west of James Bay.

ENGINEERING EDUCATION.

The address of Prof. Storm Bull, before the Section of Mechanical Science and Engineering, was on engineering education as a preliminary training for scientific research work. The proposition put forward was that engineering education as furnished in the best technical schools of the world, together with the training obtained later in life as a practising engineer, provides the best preliminary preparation for the successful prosecution of scientific research work.

## *UNIVERSITY AND EDUCATIONAL INTELLIGENCE.*

MR. A. G. ASHCROFT has been appointed Assistant Professor of Engineering at the Central College of the City and Guilds of London Institute.

DURING the winter session 1899-1900 at the University of Edinburgh, courses on practical experimental physiology, practical chemical physiology, and practical histology, will be given every week day, in addition to the usual five months' course on physiology.

AMONG the addresses to be delivered at the opening of the Medical Schools in the beginning of October are the following:—At the Middlesex Hospital the introductory address will be delivered by Mr. John Murray. At St. George's Hospital the introductory address will be given by Dr. Howship Dickinson. At University College the session will be opened by Dr. G. F. Blacker. At St. Mary's Hospital the address will be given by Mr. H. G. Plimmer. At Charing Cross Hospital the address will be delivered by Dr. Mitchell Bruce. At Guy's the term begins on October 2, when the first meeting of the session of the Physical Society will be held at 8, in the new physiological theatre. Sir Samuel Wilks will preside. At the London School of Medicine for Women the introductory address will be given by the dean, Mrs. Garrett Anderson, after which the prizes for the past year will be distributed. The winter session of the London School of Tropical Medicine will open on October 2, when the new school will be formally opened to students. At St. Thomas's Hospital the session will open on October 3, when the prizes will be distributed by Prof. Clifford Allbutt. The winter session at Mason College, Birmingham, will begin on October 2, when Sir William Gairdner will deliver the introductory address. At University College of South Wales and Monmouthshire, Cardiff, the address will be given on October 6 by Prof. A. W. Hughes. At Yorkshire College, Leeds, the address will be given on October 2, and the prizes distributed by Dr. Byrom Bramwell. The session at University College, Liverpool, will begin on October 3 with an address by the Rev. S. A. Thompson-Yates, who will afterwards distribute the prizes. The introductory lecture at Queen's College, Manchester, will be given on October 2 by Sir J. Crichton Browne.

## *SCIENTIFIC SERIAL.*

*American Journal of Science*, September.—On the gas thermometer at high temperatures, by L. Holborn and A. L. Day. The authors seek for a type of gas pyrometer yielding the most trustworthy results, and eventually decide in favour of the iridio-platinum bulb as against porcelain. They fill the bulb with nitrogen, and use a saltpetre bath up to 750°, a zinc bath up to 900°, and electric heating for still higher temperatures, since flame gases pass bodily through the metal.—On the flicker photometer, by O. N. Rood. The general idea of the photometer, which is independent of colour, is that the differently coloured beams of light traversing its axis should illuminate the two surfaces of a rectangular prism, facing the eye, and that by the oscillations of a cylindrical concave lens its illuminated surfaces should alternately and in rapid succession be presented to the eye. The resulting flicker vanishes when the two surfaces have the same luminosity.—A quantitative investigation of the coherer, by A. Trowbridge. The greater the charging potential of the coherer, the more rapid is the rise of the conductivity per unit increase in quantity of electricity discharged. Probably every coherer has a critical value of the difference of potential below which it will not act. In the ball coherer used this was 8 volts.—Double ammonium phosphates of beryllium, zinc, and cadmium in analysis, by Martha Austin. The preparation of these double ammonium phosphates is described in detail, and their utility in analytical processes is indicated.—An Albertite-like asphalt in the Choctaw Nation, Indian Territory, by J. A. Taff. The mineral, in both its physical and chemical properties, is shown to be an asphalt, and only differs from albertite in its solubility in turpentine. It occurs in veins from 4 to 25 feet thick.—A new meteorite from Murphy, Cherokee County, N.C., by H. L. Ward. The siderite described has a square fracture unusual in iron meteorites.—On the separation of alumina from molten magmas, and the formation of corundum, by J. H. Pratt. The separation of alumina is well illustrated in nature in the occurrence of corundum, spinel, and chromite in the rocks of the peridotite group. Experiments in the laboratory show that the separation of alumina as corundum from molten magmas is dependent upon the composition of the chemical compounds that are the basis of the magma, upon the oxides that are dissolved with the alumina, and upon the amount of the alumina itself. When the magma is composed of a magnesium silicate without excess of magnesia, all the alumina held by such a magma will separate out as corundum.

## *SOCIETIES AND ACADEMIES.*

PARIS.

**Academy of Sciences**, September 11.—M. Maurice Lévy in the chair.—On a new form of the equations of dynamics, by M. P. Appell. Some remarks on the new form of equation indicated in the *Comptes rendus* of August 7 and 28. The results obtained can be expressed in one theorem, with which is connected the principle of least constraint of Gauss.—The Perseids of 1899, by M. G. Flammarion. The paper gives the results of the observations of MM. Antoniadi and Mathieu at the observatory of Juvisy on August 11, 12 and 13. The results are given in tabular form, and the directions of the meteors observed are shown upon a map.—Remarks by M. Bouquet de la Grye on the above paper. It would be possible to utilise shooting stars as a means of determining differences of longitude between places unprovided with the telegraph.—On some geometrical relations between two systems of points defined by algebraic equations, by M. S. Mangeot.

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THURSDAY, SEPTEMBER 28, 1899.

## *INCANDESCENT GAS LIGHTING.*

*L'éclairage à Incandescence.* Par P. Truchot. Pp. x + 255. (Paris : Georges Carré et C. Naud, 1899.)

IN looking back to the achievements of the past half-century, few domestic improvements will strike the observer more forcibly than the advances made in the development of light from coal gas. In the early fifties the metal flat flame and argand burners were looked upon as so satisfactory and so little likely to find a rival, that practically no efforts were made to improve them, and it was only in 1852 when the late Sir Edward Frankland first made his double chimney argand—afterwards known as the Bowditch burner—in which he led the air supply down between two glass cylinders surrounding the flame, and so utilised some of the heat which would otherwise have been wasted to heat the air supplied to the flames, and found as the result a distinct increase in illuminating power, that the idea arose that it was possible to obtain more than the two to three candles of light per cubic foot of gas consumed which the best burners then gave.

Frankland's burner marks the inception of the idea of regeneration as applied to an illuminating flame, an idea perfected by Siemens in 1879 and followed by a number of regenerative burners which doubled, and in some cases nearly trebled, the light obtainable from coal gas as compared with the ordinary burner.

At the same period that the regenerative burner was struggling into prominence, Bourbouze, and later Lewis, devised a method of producing light from coal gas by burning it in a long bunsen burner, and making the flame impinge upon a mantle of fine platinum gauze, which heated to high incandescence gave more light than would have been emitted by the gas if burnt in an ordinary burner; and although this process never achieved much success owing to the fact that platinum soon got acted upon and lost its power of light emissivity, yet it was undoubtedly the forerunner of the incandescent mantle of to-day which has revolutionised our ideas as to artificial illumination, and yields ten times as much light for the same gas consumption as the ordinary No. 5 flat flame burner.

So important has incandescent lighting become, and so abundant is the literature with regard to it, that the time had clearly arrived for it to be collected and welded into a handbook that should prove a guide and companion to all working in this branch of industry. This task has been undertaken by M. Truchot, who in "L'éclairage à incandescence par le gaz et les liquides gazéifiés" has given us a concise record of the history of incandescent lighting and a work of both theoretical and practical importance.

In the twelve chapters of which the book consists, the author passes in review the properties and production of light, photometry, the proper distribution of light, the theories of Drossbach, St. John, Westphaal, Killing, Bunte and others who have attempted to explain the cause of the high incandescence of the metallic oxides forming the mantle skeleton, an excellent history of incandescent lighting and a full account of the various minerals employed as a source of the rare earths and their treatment. Especially valuable will be found the description of the various methods of making the mantle and the chief points to be observed.

The author then passes to the various forms of bunsen burner, and the results which can be obtained from them, but hardly gives sufficient credit to Bandsept's inventions, which practically cover the ground upon which the chief advances in this direction have since been made. It would have been better also if a chapter had been devoted to the theory of the bunsen burner, as it would have made the differences existing between the various forms of burner clearer.

Very excellent in its way also is the chapter devoted to the lighting of the burners, and the effect which this has upon the life of the mantle. The author also goes fairly fully into incandescent mantle lamps for use with alcohol, petroleum and other easily gasifiable hydrocarbons.

The book concludes with a review of the use of incandescent lighting for railway carriages, lighthouses, photography, &c., and comparisons of incandescent light with other systems; whilst the list of French patents for mantles and burners forms a useful finish to the work.

M. Truchot has done his work well, and his book should be in the hands of everybody interested in incandescent mantle lighting.

## *AN AMERICAN TEXT-BOOK OF GEOMETRY.*

*New Plane and Solid Geometry.* By W. W. Beman and D. E. Smith. Pp. x + 382. (Boston, U.S.A. : Ginn and Co., 1899.)

THE Americans are an eminently practical people, and in seeking for the path of least resistance towards any desired end they are happily free from the shackles of inherited prejudice and irrational reverence for established tradition. This makes their mathematical text-books very instructive reading; and although in some cases the desire for simplicity leads to a certain superficiality, this reproach cannot be fairly applied to their mathematical literature as a whole. Every reasonable person must admit that the simplest way of demonstrating a mathematical truth is the best one; and that energy wasted on the rudiments is so much loss of valuable time which might have been spent with profit otherwise.

The "New Plane and Solid Geometry," which is a revised edition of a work first published in 1895, illustrates very well the attitude of two experienced and competent American professors towards the problem of teaching elementary geometry. It is not to be expected that their work will meet with universal approval in all its details; but it has many conspicuous merits which cannot fail to commend themselves, and deserves to be carefully studied by every teacher, whatever his personal views may be.

The first thing to notice is the order and proportion which the authors have succeeded in maintaining. After a short, but very useful, introduction, there are eight Books dealing respectively with rectilineal figures; equality of polygons; circles; ratio and proportion; mensuration and regular polygons; lines and planes in

space; polyhedra; the cylinder, cone and sphere, and similar solids. At the end of the book will be found numerical tables, a biographical table, a table of etymologies and an index. The space allotted to the different sections is comparable with their relative importance, and proper emphasis is laid on fundamental ideas such as congruence, symmetry and similarity.

Another very important feature is that the student is consistently stimulated and encouraged to think for himself. Marginal queries are frequently inserted, in order that he may justify the statements in the text; and some of the proofs are given merely in outline for the reader to fill up in detail. On the other hand, figures and hints are given with the more difficult exercises. The appendix to Book iii., and other paragraphs inserted from time to time, ought to be of great help in teaching the student how to acquire the difficult art of proceeding from the unknown to the known by the method of analysis.

In the theory of parallels, the authors adopt Playfair's axiom; and their treatment of ratio is entirely arithmetical. In their opinion the purely geometric treatment is too difficult for the beginner. On this point opinions differ, and will probably continue to do so: at the same time the arithmetical theory is here given in as nearly rigorous a form as the beginner is likely to appreciate. Thus it is properly stated as an assumption that a geometric magnitude may be represented by a number; and the transition from the commensurable to the incommensurable case is made by the classic process of exhaustion. Of course the strict arithmetical theory is at least as hard as the geometrical one, because it involves, besides the assumption above stated, either Dedekind's theory of irrational numbers or something equivalent to it.[1] But there is something to be said in favour of beginning with a provisional theory, admittedly imperfect, o be made more precise later on. It would be easy to add, in a future edition, an appendix giving the strict arithmetical and geometrical theories.

In the discussion of the mensuration of the circle and other similar questions, the authors have avoided an error into which writers who adopt the arithmetical method are very apt to fall. They explicitly state the assumption that the circumference of a circle is the limit of the perimeter of an inscribed or circumscribed regular polygon, and then make use of the proved proposition that if, while approaching their respective limits, two variables have a constant ratio, their limits have that ratio. It is rather curious, by the by, that they omit to prove that the volume of a pyramid is the limit of the sum of the volumes of the usual set of inscribed prisms.

In the text, which is beautifully printed by the Athenæum Press, free use is made of abbreviations. The notation *ab* for the rectangle contained by the segments denoted by *a* and *b* will be objected to by some people; but it really needs no justification, because the analogy which it suggests is too useful to be ignored, and if the student cannot, after due warning, distinguish *ab*, the area of a rectangle, from *ab*, the product of two numbers, it is entirely his own fault.

The figures are very good; those on solid geometry have been very carefully drawn, and are nearly as effective as models would be. This is a great help to the beginner: he should bear in mind, however, that he must eventually be able to use a less pictorial figure, or even construct a diagram mentally in cases where an actual figure is too complicated to be useful. We should be rather inclined to suggest beginning with the more pictorial figures, and gradually reducing them to pure diagrams. Between a picture and a diagram there is the same sort of difference as there is between a photograph of an electrometer and a working drawing of the same instrument.

G. B. M.

[1] It may be remarked, in passing, that Euclid's test of the equality of two ratios really amounts to the establishment of the identity of two *Schnitte*, as Dedekind calls them; for if $mA >=< nB$ according as $mC >=< nD$, the series of rational numbers $m/n$ for which $mA > nB$ defines a *Schnitt*, and this is identical with the series for which $mC > nD$.

## OUR BOOK SHELF.

*An Elementary Course of Mathematics.* By H. S. Hall and F. H. Stevens. Pp. ix + 342. (London: Macmillan and Co., Ltd., 1899.)

IN preparing this book the object kept in mind was, as we are told in the preface, to provide in a simple and inexpensive volume a short course of arithmetic, algebra and Euclid specially adapted to the requirements of students who, after leaving school, desire to continue their study of elementary mathematics by partly attending evening classes and partly working privately at home.

To attain the end in view, the compilers, in the first portion on arithmetic, have restricted themselves to simply providing the student with a series of progressive exercises arranged to extend over a winter session of thirty weeks; a few additions, exercises with notes and hints, conclude this portion.

Algebra is next dealt with, and no previous knowledge is here assumed, so that a progressive but elementary course with numerous examples is given, covering the usual ground up to quadratic equations. In the last section on Euclid only the first book is considered. In the case of each proposition a few notes and exercises will help the reader to master this book, while additional theorems and a large set of appropriate examples are added for further practice.

For the purpose for which it is intended, this elementary course is well adapted.

*Carvell's Nursery Handbook, with Hints.* By J. M. Carvell. Pp. 70. (London: Barber, 1899.)

THE contents of this "Nursery Handbook" are arranged under a number of headings; for instance, "The Nursery," "Sleeping," "Clothing," "Feeding," &c. But in each section the hints given seem to be selected at haphazard; small details in some places are noted, while many points of importance are omitted.

In fact, the book seems too disjointed to be of real value, and the information too scanty to serve as a practical guide. In many instances the directions are so short that without amplification they might easily be misinterpreted.

*Chats about the Microscope.* By Henry C. Shelley. Pp. 101. (London: The Scientific Press, Ltd., 1899.)

YOUNG naturalists will find in this volume many useful hints on the collection and preparation of common objects for microscopical study, and will be guided to make observations of a number of minute organisms easily obtained.

## LETTERS TO THE EDITOR.

*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### The Life of a Star.

THE letter of Prof. Perry on "The Life of a Star," published in your issue of July 13, is of interest to astronomers; and as the author of it evidently aims to be fair, I think it worth while to set right a misconception into which he has fallen. His reference to my paper in the *Astronomical Journal* (No. 455) shows that he has misconstrued the meaning of the symbol K in the formula $T = \frac{K}{R}$. That paper was unfortunately very much abbreviated, and as I was not concerned with the analytical investigation of K, this constant was not sufficiently explained. Yet in my first note on this law in the *A. J.* (453), which he probably overlooked, it was announced that "K is a constant different for each body." Thus the constant K is not, as Prof. Perry supposes, the same for the whole universe, but varies from star to star, being a function of the mass, specific heat, emissive power, &c., into which we need not go at present.

At the time of writing the paper in the *A. J.* (455) I had not seen the early paper by Ritter in *Wiedemann's Annalen*, 1878, s. 543,[1] where he has reached by a different process a similar formula

$$T_0 r_0 = Tr,$$

and anticipated a number of the conclusions to which I came independently. Ritter even applied this law to the temperature of the solar nebula when its periphery extended to the orbit of Neptune, and sagaciously observes that his conclusions do not agree with current views, but are yet uncontradicted by known facts.

As I have prepared for the St. Louis Academy of Sciences a paper in which this whole matter is discussed with some detail, I will here merely summarise a few of the chief results. Suffice it to say that the formula $T = \frac{K}{R}$ is shown to express a law of the utmost generality, for masses composed of one kind of gas; and that even when the body is of heterogeneous constitution, made up of interpenetrating globes of different gases, the law suffers no essential modification except at very long intervals, when it would take the form

$$T = \frac{K(1 + \beta t)}{R},$$

where $\beta$ is a certain small secular coefficient, and $t$ the time. For a great epoch the term depending on $\beta$ might be wholly neglected.

The only hypothesis underlying the investigation is that of convective equilibrium, the validity of which is generally recognised by physical investigators. In order that the reader may see how far from metaphysical my argument really is, I add an elementary derivation of the law of temperature.

Suppose a gaseous globe of radius $R_0$ to be held in convective equilibrium by the attraction, pressure and temperature of its particles (the density and temperature decreasing from the centre to the surface), and let the temperature beneath the surface layer be $T_0$. Let $P_0$ be the gravitational attraction exerted upon the thin layer of matter covering a unit surface of the globe, which may be regarded as the base of an elemental cone extending to the centre. Then suppose the globe to shrink by loss of heat to a radius R. If the original element of mass still covered a unit area, the pressure exerted upon its lower surface would thereby become $P = P_0\left(\frac{R_0}{R}\right)^2$. But since the area of the initial sphere surface has shrunk to $S = S_0\left(\frac{R}{R_0}\right)^2$, the area of the elemental conical base has diminished in the same ratio. As the force of gravity is increased, while the area upon which the element presses is decreased correspondingly, it follows that in the condensed condition of the globe, the gravitational pressure exerted upon a unit area is $P = P_0\left(\frac{R_0}{R}\right)^4$. The forces counteracting this increased pressure are obviously the resistance due to the increase in the mean density, and a possible change in temperature which might affect the elasticity of the gas. But the density of the original mass was $\sigma_0$, and hence $\sigma = \sigma_0\left(\frac{R_0}{R}\right)$. By hypothesis the equilibrium of the globe is maintained by the elastic force of the gas under the heat developed by the gravitational shrinkage of the mass. If therefore the globe was in equilibrium when the gas just beneath the surface layer had a mean temperature $T_0$, to remain in equilibrium in the condensed condition, $T_0$ must be multiplied by $\frac{R_0}{R}$. As $T_0 R_0$ = constant, we may write the law of temperature.

$$T = \frac{K}{R}.$$

This law of course applies to each layer of the globe, and thus to its mean temperature, and is obviously general for all gaseous celestial bodies condensing under the law of gravitation. Some persons who do not fully understand the problem under consideration have asserted that the functions which express the distribution of density and temperature with respect to the radius, are altered by shrinkage, so that the law then breaks down, or rather is not proved to hold true. It is perhaps worth while to show the error of this view.

Lord Kelvin has shown (*Phil. Mag.*, 1887, p. 287) that the temperature distribution throughout the globe must satisfy the differential equation

$$\frac{d^2\theta}{dx^2} + \frac{\theta^\kappa}{x^4} = 0,$$

where $\theta$ is the temperature, $x$ a function of the radius, and $\kappa$ a constant. If $\theta = \phi(x)$ be a particular solution of this equation, the second differential coefficients

$$\phi''(x) = -\{\phi(x)\}^\kappa x^{-4},$$

and

$$\phi''(\mu x) = -\{\phi(\mu x)\}^\kappa \mu^{-4} x^{-4};$$

and the general solution is shown to be of the form

$$\theta = C\phi\{xC^{-\frac{1}{4}}(\kappa^{-1})\},$$

where C and $\kappa$ are constants.

Under convective equilibrium the mass will contract in such a way that the particles in any concentric sphere surface do not penetrate those surfaces adjacent, that is, the new ordinate $\xi$ of any particle is defined by the equation $\xi = \alpha x$, where $\alpha$ is a numerical coefficient smaller than unity; and hence

$$\theta = C\phi\{\xi C^{-}(\kappa^{-1})\}$$

will be a solution of exactly the same form as the first. A curve defined by the equation

$$y = \psi(r^{-1})$$

will give the absolute temperature from the centre to the surface. In like manner another curve

$$\eta = \{\psi(r^{-1})\}^\kappa$$

will give the distribution of density with respect to the radius.

Shrinkage by which the variables become $\rho = \alpha r$ will not change the character of these two functions; and hence the distribution of density and temperature is rigorously the same after contraction as before. This result continues to hold so long as the body is wholly gaseous and obeys the laws of convective equilibrium.

Prof. Perry has examined at some length the question of radiation, and he deserves our thanks for the interesting suggestions he has advanced. Yet I have considered our knowledge based on terrestrial experiment too limited to furnish any conclusion which can be confidently applied to the conditions existing in the heavens, except that the masses are always in convective equilibrium, and that all shrinkage is determined by this condition. Accordingly the foregoing conclusions would seem to be valid generally. It seems fair to conclude that there are few branches of physical science which offer such an unexplored field as the one which relates to the life-history of stars. And though it may be assumed that forces are at work in space, of which we have little or no experimental analogy up to this time, yet it is always safe to apply known laws to the phenomena of the heavens with a view of explaining observations, and of suggesting unknown causes which may become the subject of future research.

T. J. J. SEE.

Washington, D.C., August 5.

[1] Prof. Nipher, in preparing the excellent papers which he has contributed to the St. Louis Academy of Sciences, first drew attention to this reference.

### Remarkable Lightning Flashes.

LAST September you kindly published a photograph of a multiple lightning flash taken with a moving camera. I now enclose a photograph taken at Johannesburg by Mr. G. H. Preston. I think that he must have moved his camera (Frena) unintentionally, being startled at the commencement of a very vivid flash, which seems to have lasted some considerable time, say nearly one second. At any rate there are nine distinct lightning flashes, all of identical shape. The first three, or perhaps a few more, are very strong and close together, and possibly while they were taken the camera may as yet have been

fairly stationary; its axis then moved in spiral curves while the remaining six flashes imprinted themselves.

The photograph is of interest on account of the large number of individual but otherwise identical flashes, and especially because it shows that these individual discharges follow each other at irregular intervals; and I hope that the suggestion which I made last year to study this subject may be carried out.

As on my last year's photograph, there is on this one an additional flash, which appears to be single but is much more branched than the other one. C. E. STROMEYER.

Lancefield, West Didsbury, August 21.

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IN NATURE for September 14 (p. 460), the writer on dark lightning refers to the absence of dark flashes in pictures of artificial discharge. I may perhaps draw the attention of any who are unfamiliar with Lord Armstrong's "Electric Movement in Air and Water" to Plate 34 in that book, in which is shown a very fine example of a dark fla h. Lord Armstrong describes how he obtained the discharge on p. 41. Plate 18 is also of interest in this connection. HENRY STROUD.

The Durham College of Science, Newcastle-upon-Tyne, September 18.

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I DO not see on what grounds it is concluded (p. 423) that ribbon lightning has a real existence. The appearance might easily be caused by defective vision. If the fork is not distinctly focussed on the retina, it may appear either broadened or double or multiple, especially if there is any degree of cataract in the eye. The ribbon appearance in the photograph shown in your article is surely to be explained by the camera having been moved downwards and slightly to the right, or else in the opposite direction, and three or more discharges having taken place during the time. The horizon not being sharp is further evidence. One may imagine, however, that an appearance of this kind might also arise from a discharge being repeated through the same air, but the air moving bodily between one discharge and the next: it seems to me it yet remains to be proved whether such a thing ever does occur. One would suppose that if it did, the motion of the air would not be uniform throughout the flash, and therefore the ribbon would be unequal in width in different parts.

With regard to apparently black lightning, some months ago I saw a black fork having exactly the appearance of an ordinary flash of forked lightning, only dark on the light ground of a flash of sheet lightning. I concluded the explanation to be that given by Lord Kelvin, only the curious circumstance was that I did not remember I had previously seen a bright fork of the pattern of the dark one. I have no doubt, however, that there must have been one, and that my being dazzled by it caused me to see it again, dark, as soon as there was a light background to show it. T. W. BACKHOUSE.

West Hendon House, Sunderland, September 18.

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IT is surprising that such a brilliant experimentalist as Prof. R. W. Wood does not allude to that peculiar reversal of the photographic image known as the Clayden effect.

I drew particular attention to this explanation of the dark flash in a lecture before the Royal Photographic Society this year, which is fully reported and illustrated in the *Photographic Journal* for March last.

The Clayden effect is easily verified in the following way.

Arrange the sparking terminals of a coil, horizontally, about four inches apart, with a dark background of velvet; focus a camera for the sparks, then darken the room. Place a strip of white card one inch wide near one terminal in the spark gap, uncap the lens, and expose on the card by burning one inch of magnesium wire; then remove the card and pass a spark, now place the same card near the other terminal of the spark gap, and burn another inch of magnesium wire. On developing the plate it will be found that the spark image is reversed over the latter card only.

This shows that the same amount of fog has a very different effect, whether it is deposited before or after the image. It must sometimes happen that in photographing lightning some sky fog or other fog will be deposited after the image; it therefore seems highly probable that any bright flash could be converted into a dark flash by slightly fogging the plate before development. The Clayden effect also explains why, with a number of flashes on the same plate, some may be dark and some light, and yet dark lightning probably has no real existence.

156 Clapham Road, S.W. F. H. GLEW.

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### Sedge-Warblers seizing Butterflies.

OBSERVED instances of birds capturing butterflies are so few that I venture to think the following worth putting on record. On the evening of August 12, at about 6.30 p.m., I was walking beside a dyke on Ludham Marsh, Norfolk, when my attention was attracted by the alarm notes of a pair of sedge-warblers in the reeds. I stood still, and soon caught sight of both birds within about six yards of me. Each had a butterfly in its mouth, and with my field-glass I was able to identify the species as a meadow brown (*E. Janira*) and a small white (*P. rapae*). From the behaviour of the birds, and my observation of them on subsequent days, I have no doubt that they were feeding their nestlings, though I was unable to find the nest. I may add that at the time most of the butterflies had taken up their quarters for the night on stems of reeds, &c., and that very many of the butterflies which I observed during the daytime on the marshes had very ragged and chipped wings. These injuries may have been caused by wind and contact with twigs, thorns, &c., but they were quite compatible with repeated ineffectual pecks and snips from the beaks of small birds.

OSWALD H. LATTER.

Charterhouse, Godalming, September 17.

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### Explosion of Aluminium Iodide.

I HAD two samples of aluminium iodide in two hermetically sealed glass tubes sent by a German firm. One of them was passing round the class, and the other was lying on the demonstration table. Suddenly a report was heard, and I found that the tube on the table had exploded, and its contents had been thrown out. Both the tubes were perfectly sound, and therefore there seems to be no reason to suspect that the volatile compound found an explosive mixture with the air. The temperature of the lecture room was at the time nearly 95° F. I communicate this matter to you to find out if others have had similar experience with aluminium iodide. P. L. NARASU.

Christian College, Madras, July 30.

## THE DOVER MEETING OF THE BRITISH ASSOCIATION.

THE final meeting of the general committee of the British Association was held on Wednesday in last week, for the purpose of receiving the report of the committee of recommendations. The list of grants made for various scientific purposes has already been given (p. 496). The committee also recommended that, in view of the opportunities of ethnographic inquiry which will be presented by the Indian census now beginning, the council of the Association be requested to urge the Government of India to make use of the census officers to obtain information with reference to particular races and tribes, and to attach photographers to the census officers to furnish a complete photographic series of typical specimens of the various races, of views of archaic industries, and of other facts interesting to ethnologists. This recommendation was accepted and ordered to be forwarded to the council. It was also resolved that the council be requested to recommend to Her Majesty's Government the importance of giving more prominence to botany in the training of Indian forest officers.

At the concluding general meeting of the Association, held on Wednesday, September 20, it was announced that the number of tickets issued was 1403. The usual votes of thanks were then put to the meeting and passed.

Sir G. G. Stokes proposed :—"That the best thanks of the Association be given to the Mayor and Corporation, to the local committee, and to the officers of the local sub-committees for their reception of the Association." Prof. Forsyth, in seconding the resolution, said that they should all carry away grateful recollections of the way in which they had been treated at Dover, and if the meeting had not been the largest it had certainly been very pleasant and highly successful.

The two local secretaries, Colonel Knocker and Mr. W. H. Pendlebury, responded for the local committee.

Sir John Evans proposed a vote of thanks to the President, Council, and Headmaster of Dover College for putting the college buildings at the service of the Association. In seconding the resolution Sir W. Thiselton-Dyer expressed, on behalf of the members of the Association, gratitude to the municipality and inhabitants of Dover for the reception which they had given to the Association. Some of the work this year had been of quite exceptional importance.

The Headmaster of Dover College (the Rev. W. C. Compton) acknowledged the vote of thanks.

Sir Norman Lockyer proposed a vote of thanks to Captain Winslow and the other officers of Her Majesty's ships, to Major-General Sir Leslie Rundle and Staff, and to all the inhabitants who had entertained members or conducted excursions, and to the heads of firms who had thrown open their works. He remarked that the fact that this vote of thanks included officers of Her Majesty's Navy and Army gave distinction to a meeting which otherwise had a distinctive character. For the first time members of the Association had met in the Sections together with French *confrères*, and the visit of the French Association had been marked by many little incidents showing a kindly feeling, which was national rather than local.

Sir W. H. White seconded the resolution, and Dr. Sebastian Evans briefly responded.

Sir John Murray moved that a cordial vote of thanks be given to Sir Michael Foster for his services as president of the Dover meeting.

Sir A. Binnie, in seconding the resolution, said that the success of this meeting was largely due to the tact and urbanity of the president. Sir Michael Foster in a few words acknowledged the compliment, and then declared the meeting adjourned till next September at Bradford.

On Wednesday afternoon the Mayor and Corporation of Canterbury received and entertained at luncheon the president and some of the chief officers of the Association, together with the president, Dr. Brouardel, and about a hundred members of l'Association française pour l'avancement des sciences

A brief toast list followed the luncheon. The Queen and the President of the French Republic having been successively proposed from the chair, Dean Farrar gave "Our Guests and Success to the British and French Associations for the Advancement of Science," coupling with it the names of the presidents of the two Associations. In the course of his remarks he said there was no means of human knowledge which the human mind could devote itself to study with more profit or advantage than the knowledge of science. It was right to do honour to those whose efforts had illuminated darkness, removed ignorance and extended man's horizon.

Dr. Brouardel and Sir Michael Foster responded.

On Thursday, September 21, the president, officials and about three hundred members of the British Association proceeded from Dover to Boulogne to return the visit of the French Association. From the *Times* report we learn that at Boulogne they were received by leading members of the French Association, who entertained them to breakfast, and afterwards they were officially welcomed at the Town Hall by the Mayor of Boulogne. Later in the day they were entertained at a banquet in the ball-room of the casino by the municipality of the town, and speeches of compliment and welcome were delivered by the Prefect of the Pas de Calais, the Director of Primary Education as delegate of the French Government, Sir Michael Foster and Dr. Brouardel. Special commemorative medals were presented by the French Association to their president and Sir M. Foster. Subsequently the visitors were present at the unveiling of a monument of Dr. Duchesne—who died about twenty-five years ago and was distinguished by his application of electricity to nervous disorders—and of a black marble plaque upon the house in which Thomas Campbell, the poet (who devoted much time and attention to many public matters, including the University of London), died at Boulogne in 1844.

No account of the meeting which has just been concluded would be complete without a reference to two sermons on "Some of the Mutual Influences of Theology and the Natural Sciences," preached in St Mary's Church for members of the Association by the Ven. J. M. Wilson, Archdeacon of Manchester. The enlarged conception of the study of theology, as presented by Archdeacon Wilson, will be made the subject of deep consideration by many thoughtful minds ; and men of science cannot but be gratified at the liberal spirit which permeated it. No longer is it asserted that the methods and results of theology and science are antagonistic, but rather that the two exert beneficial influences upon each other, and that the scientific method should be applied to theological research. The expression of such rational views should do much to overcome the prejudice which still exists against scientific habits of thought, and to create sympathy between men engaged in advancing natural and theological knowledge. The common meeting ground is the search for truth, so far as the human mind can follow it.

### SECTION E.

#### GEOGRAPHY.

OPENING ADDRESS BY SIR JOHN MURRAY, K.C.B., F.R.S., LL.D., PRESIDENT OF THE SECTION.

IN his opening Address to the members of the British Association at the Ipswich meeting, the President cast a retrospective glance at the progress that had taken place in the several branches of scientific inquiry from the time of the formation of the Association in 1831 down to 1895, the year in which

were published the last two of the fifty volumes of Reports containing the scientific results of the voyage of H.M.S. *Challenger*. In that very able and detailed review there is no reference whatever to the work of the numerous expeditions which had been fitted out by this and other countries for the exploration of the depths of the sea, nor is there any mention of the great advance in our knowledge of the ocean during the period of sixty-five years then under consideration. This omission may be accounted for by the fact that, at the time of the formation of the British Association, knowledge concerning the ocean was, literally speaking, superficial. The study of marine phenomena had hitherto been almost entirely limited to the surface and shallow waters of the ocean, to the survey of coasts and of oceanic routes directly useful for commercial purposes. Down to that time there had been no systematic attempts to ascertain the physical and biological conditions of those regions of the earth's surface covered by the deeper waters of the ocean; indeed, most of the apparatus necessary for such investigations had not yet been invented.

The difficulties connected with the exploration of the greater depths of the sea arise principally from the fact that, in the majority of cases, the observations are necessarily indirect. At the surface of the ocean direct observation is possible, but our knowledge of the conditions prevailing in deep water, and of all that is there taking place, is almost wholly dependent on the correct working of instruments, the action of which at the critical moment is hidden from sight.

It was the desire to establish telegraphic communication between Europe and America that gave the first direct impulse to the scientific exploration of the great ocean-basins, and at the present day the survey of new cable routes still yields each year a large amount of accurate knowledge regarding the floor of the ocean. Immediately before the *Challenger* Expedition there was a marked improvement in all the apparatus used in marine investigations, and thus during the *Challenger* Expedition the great ocean-basins were for the first time systematically and successfully explored. This expedition, which lasted for nearly four years, was successful beyond the expectations of its promoters, and opened out a new era in the study of oceanography. A great many sciences were enriched by a grand accumulation of new facts. Large collections were sent and brought home, and were subsequently described by specialists belonging to almost every civilised nation. Since the *Challenger* Expedition there has been almost a revolution in the methods employed in deep-sea observations. The most profound abysses of the ocean are now being everywhere examined by sailors and scientific men with increasing precision, rapidity and success.

The recognition of oceanography as a distinct branch of science may be said to date from the commencement of the *Challenger* investigations. The fuller knowledge we now possess about all oceanic phenomena has had a great modifying influence on many general conceptions as to the nature and extent of those changes which the crust of the earth is now undergoing and has undergone in past geological times Our knowledge of the ocean is still very incomplete. So much has, however, already been acquired that the historian will, in all probability, point to the oceanographical discoveries during the past forty years as the most important addition to the natural knowledge of our planet since the great geographical voyages associated with the names of Columbus, Da Gama, and Magellan, at the end of the fifteenth and the beginning of the sixteenth centuries.

It is not my intention on this occasion to attempt anyth ng like a general review of the present state of oceanographic science. But, as nearly all the samples of marine deposits collected during the past thirty years have passed through my hands, I shall endeavour briefly to point out what, in general, their detailed examination teaches with respect to the present condition of the floor of the ocean, and I will thereafter indicate what appears to me to be the bearing of some of these results on speculations as to the evolution of the existing surface features of our planet.

### *Depth of the Ocean.*

All measurements of depth, by which we ascertain the relief of that part of the earth's crust covered by water, are referred to the sea-surface; the measurements of height on the land are likewise referred to sea-level. It is admitted that the ocean has a very complicated undulating surface, in consequence of the attraction which the heterogeneous and elevated portions of the lithosphere exercise on the liquid hydrosphere. In the opinion of geodesists the geoid may in some places depart from the figure of the spheroid by 1000 feet. Still it is not likely that this surface of the geoid departs so widely from the mean ellipsoidal form as to introduce a great error into our estimates of the elevations and depressions on the surface of the lithosphere.

The soundings over the water-surface of the globe have accumulated at a rapid rate during the past fifty years. In the shallow water, where it is necessary to know the depth for purposes of navigation, the soundings may now be spoken of as innumerable; the 100-fathom line surrounding the land can therefore often be drawn in with much exactness. Compared with this shallow-water region, the soundings in deep water beyond the 100-fathom line are much less numerous; each year, however, there are large additions to our knowledge. Within the last decade over ten thousand deep soundings have been taken by British ships alone. The deep soundings are scattered over the different ocean-basins in varying proportions, being now most numerous in the North Atlantic and South-west Pacific, and in these two regions the contour-lines of depth may be drawn in with greater confidence than in the other divisions of the great ocean-basins. It may be pointed out that 659 soundings taken quite recently during cable surveys in the North Atlantic, although much closer together than is usually the case, and yielding much detailed information to cable engineers, have, from a general point of view, necessitated but little alteration in the contour-lines drawn on the *Challenger* bathymetrical maps published in 1895. Again, the recent soundings of the German s.s. *Valdivia* in the Atlantic, Indian, and Southern Oceans have not caused very great alteration in the positions of the contour-lines on the *Challenger* maps, if we except one occasion in the South Atlantic when a depth of 2000 fathoms was expected and the sounding machine recorded a depth of only 536 fathoms, and again in the great Southern Ocean when depths exceeding 3000 fathoms were obtained in a region where the contour-lines indicated between 1000 and 2000 fathoms. This latter discovery suggests that the great depth recorded by Ross to the south-east of South Georgia may not be very far from the truth.

I have redrawn the several contour-lines of depth in the great ocean-basins, after careful consideration of the most recent data, and these may now be regarded as a somewhat close approximation to the actual state of matters, with the possible exception of the great Southern and Antarctic Oceans, where there are relatively few soundings, but where the projected Antarctic Expeditions should soon be at work. On the whole, it may be said that the general tendency of recent soundings is to extend the area with depths greater than 1000 fathoms, and to show that numerous volcanic cones rise from the general level of the floor of the ocean-basins up to various levels beneath the sea-surface.

The areas marked out by the contour-lines of depth are now estimated as follows:—

| | Fms. | Sq. geo. m. | Per cent. |
|---|---|---|---|
| Between the shore and | 100 | ... 7,000,000 | ... (or 7 of the sea-bed) |
| ,, 100 ,, | 1000 | .. 10,000,000 | ... (or 10 ,, ,, ) |
| ,, 1000 ,, | 2000 | ... 22,000,000 | ... (or 21 ,, ,, ) |
| ,, 2000 ,, | 3000 | ... 57,000,000 | ... (or 55 ,, ,, ) |
| Over 3000 fathoms | ... | ... 7,000,000 | ... (or 7 ,, ,, ) |
| | | 103,000,000 | 100 |

From these results it appears that considerably more than half of the sea-floor lies at a depth exceeding 2000 fathoms, or over two geographical miles. It is interesting to note that the area within the 100 fathom line occupies 7,000,000 square geographical miles, whereas the area occupied by the next succeeding 900 fathoms (viz. between 100 and 1000 fathoms) occupies only 10,000,000 square geographical miles. This points to a relatively rapid descent of the sea-floor along the continental slopes between 100 and 1000 fathoms, and therefore confirms the results gained by actual soundings in this region, many of which indicate steep inclines or even perpendicular cliffs. Not only are the continental slopes the seat of many deposit-slips and seismic disturbances, but Mr. Benest has given good reasons for believing that underground rivers sometimes enter the sea at depths beyond 100 fathoms, and there bring about sudden changes in deep water. Again, the relatively large area covered by the continental shelf between the shore-line and 100 fathoms points to the wearing away of the land by current and wave action.

On the *Challenger* charts all areas where the depth exceeds

3000 fathoms have been called "Deeps," and distinctive names have been conferred upon them. Forty-three such depressions are now known, and the positions of these are shown on the map here exhibited; twenty-four are situated in the Pacific Ocean, three in the Indian Ocean, fifteen in the Atlantic Ocean, and one in the Southern and Antarctic Oceans. The area occupied by these thirty-nine deeps is estimated at 7,152,000 square geographical miles, or about 7 per cent. of the total water-surface of the globe. Within these deeps over 250 soundings have been recorded, of which twenty-four exceed 4000 fathoms, including three exceeding 5000 fathoms.

Depths exceeding 4000 fathoms (or four geographical miles) have been recorded within eight of the deeps, viz. in the North Atlantic within the Nares Deep; in the Antarctic within the Ross Deep; in the Banda Sea within the Weber Deep; in the North Pacific within the Challenger, Tuscarora, and Supau Deeps; and in the South Pacific within the Aldrich and Richards Deeps. Depths exceeding 5000 fathoms have been hitherto recorded only within the Aldrich Deep of the South Pacific, to the east of the Kermadecs and Friendly Islands, where the greatest depth is 5155 fathoms, or 530 feet more than five geographical miles, being about 2000 feet more below the level of the sea than the summit of Mount Everest in the Himalayas is above it. The levels on the surface of the lithosphere thus oscillate between the limits of about ten geographical miles (more than eighteen kilometres).

*Temperature of the Ocean-floor.*

Our knowledge of the temperature on the floor of the ocean is derived from observations in the layers of water immediately above the bottom by means of deep-sea thermometers, from the electric resistance of telegraph cables resting on the bed of the great ocean-basins, and from the temperature of large masses of mud and ooze brought up by the dredge from great depths. These observations are now sufficiently numerous to permit of some general statements as to the distribution of temperature over the bottom of the great oceans.

All the temperatures recorded up to the present time in the sub-surface waters of the open ocean indicate that at a depth of about 100 fathoms seasonal variation of temperature disappears. Beyond that depth there is a constant, or nearly constant, temperature at any one place throughout the year. In some special positions, and under some peculiar conditions, a lateral shifting of large bodies of water takes place on the floor of the ocean at depths greater than 100 fathoms. This phenomenon has been well illustrated by Prof. Libbey off the east coast of North America, where the Gulf Stream and Labrador Current run side by side in opposite directions. This lateral shifting cannot, however, be called seasonal, for it appears to be effected by violent storms, or strong off-shore winds bringing up colder water from considerable depths to supply the place of the surface drift, so that the colder water covers stretches of the ocean's bed which under normal conditions are overlaid by warmer strata of water. Sudden changes of temperature like these cause the destruction of innumerable marine animals, and produce very marked peculiarities in the deposits over the areas thus affected.

It is estimated that 92 per cent. of the entire sea-floor has a temperature lower than 40° F. This is in striking contrast to the temperature prevailing at the surface of the ocean, only 16 per cent. of which has a mean temperature under 40° F. The temperature over nearly the whole of the floor of the Indian Ocean in deep water is under 35° F. A similar temperature occurs over a large part of the South Atlantic and certain parts of the Pacific, but at the bottom of the North Atlantic basin and over a very large portion of the Pacific the temperature is higher than 35° F. In depths beyond 2000 fathoms, the average temperature over the floor of the North Atlantic is about 2° F. above the average temperature at the bottom of the Indian Ocean and South Atlantic, while the average temperature of the bed of the Pacific is intermediate between these.

It is admitted that the low temperature of the deep sea has been acquired at the surface in Polar and sub-Polar regions, chiefly within the higher latitudes of the southern hemisphere, where the cooled surface water sinks to the bottom and spreads slowly over the floor of the ocean into equatorial regions. These cold waters carry with them into the deep sea the gases of the atmosphere, which are everywhere taken up at the surface according to the known laws of gas absorption. In this way myriads of living animals are enabled to carry on their existence at all depths in the open ocean. The nitrogen remains more or less constant at all times and places, but the proportion of oxygen is frequently much reduced in deep water, owing to the processes of oxidation and respiration which are there going on.

The deep sea is a region of darkness as well as of low temperature, for the direct rays of the sun are wholly absorbed in passing through the superficial layers of water. Plant-life is in consequence quite absent over 93 per cent. of the bottom of the ocean, or 66 per cent. of the whole surface of the lithosphere. The abundant deep-sea fauna, which covers the floor of the ocean, is therefore ultimately dependent for food upon organic matter assimilated by plants near its surface, in the shallower waters near the coast-lines, and on the surface of the dry land itself.

As has been already stated, about 7,000,000 square geographical miles of the sea-floor lies within the 100-fathom line, and this area is in consequence subject to seasonal variations of temperature, to strong currents, to the effects of sunlight, and presents a great variety of physical conditions. The planktonic plant-life is here reinforced by the littoral sea-weeds, and animal-life is very abundant. About 40 per cent. of the water over the bottom of this shallow-water area has a mean temperature under 40° F., while 20 per cent. has a mean temperature between 40° and 60° F., and 40 per cent. a temperature of over 60° F.

It follows from this that only 3 per cent. of the floor of the ocean presents conditions of temperature favourable for the vigorous growth of corals and those other benthonic organisms which make up coral reefs and require a temperature of over 60° F. all the year round. On the other hand, more than half of the surface of the ocean has a temperature which never falls below 60° F. at any time of the year. In these surface-waters with a high temperature, the shells of Pelagic Molluscs, Foraminifera, Algæ, and other planktonic organisms are secreted in great abundance, and fall to the bottom after death.

It thus happens that, at the present time, over nearly the whole floor of the ocean we have mingled in the deposits the remains of organisms which had lived under widely different physical conditions, since the remains of organisms which lived in tropical sunlight, and in water at a temperature above 80° F., all their lives, now lie buried in the same deposit on the sea-floor together with the remains of other organisms which lived all their lives in darkness and at a temperature near to the freezing point of fresh water.

*Marine Deposits on the Ocean-floor.*

The marine deposits now forming over the floor of the ocean present many interesting peculiarities according to their geographical and bathymetrical position. On the continental shelf, within the 100-fathom line, sands and gravels predominate, while on the continental slopes beyond the 100-fathom line, Blue Muds, Green Muds, and Red Muds, together with Volcanic Muds and Coral Muds, prevail, the two latter kinds of deposits being, however, more characteristic of the shallow water around oceanic islands. The composition of all these Terrigenous Deposits depends on the structure of the adjoining land. Around continental shores, except where coral reefs, limestones, and volcanic rocks are present, the materials consist principally of fragments and minerals derived from the disintegration of the ancient rocks of the continents, the most characteristic and abundant mineral species being quartz. River detritus extends in many instances far from the land, while off high and bold coasts, where no large rivers enter the sea, pelagic conditions may be found in somewhat close proximity to the shore-line. It is in these latter positions that Green Muds containing much glauconite, and other deposits containing many phosphatic nodules, have for the most part been found; as, for instance, off the eastern coast of the United States, off the Cape of Good Hope, and off the eastern coasts of Australia and Japan. The presence of glauconitic grains and phosphatic nodules in the deposit at these places appears to be very intimately associated with a great annual range of temperature in the surface and shallow waters, and the consequent destruction of myriads of marine animals. As an example of this phenomenon may be mentioned the destruction of the tile-fish in the spring of 1882 off the eastern coast of North America, when a layer six feet in thickness of dead fish and other marine animals was believed to cover the ocean floor for many square miles.

In all the Terrigenous Deposits the evidences of the mechanical action of tides, of currents, and of a great variety of physical conditions, may almost everywhere be detected, and it is possible

to recognise in these deposits an accumulation of materials analogous to many of the marine stratified rocks of the continents, such as sandstones, quartzites, shales, marls, greensands, chalks, limestones, conglomerates, and volcanic grits.

With increasing depth and distance from the continents the deposits gradually lose their terrigenous character, the particles derived directly from the emerged land decrease in size and in number, the evidences of mechanical action disappear, and the deposits pass slowly into what have been called Pelagic Deposits at an average distance of about 200 miles from continental coast-lines. The materials composing Pelagic Deposits are not directly derived from the disintegration of the continents and other land-surfaces. They are largely made up of the shells and skeletons of marine organisms secreted in the surface waters of the ocean, consisting either of carbonate of lime, such as Pelagic Molluscs, Pelagic Foraminifera, and Pelagic Algæ, or of silica, such as Diatoms and Radiolarians. The inorganic constituents of the Pelagic Deposits are for the most part derived from the attrition of floating pumice, from the disintegration of water-logged pumice, from showers of volcanic ashes, and from the débris ejected from submarine volcanoes, together with the products of their decomposition. Quartz particles, which play so important a *rôle* in the Terrigenous Deposits, are almost wholly absent, except where the surface waters of the ocean are affected by floating ice, or where the prevailing winds have driven the desert sands far into the oceanic areas. Glauconite is likewise absent from these abysmal regions. The various kinds of Pelagic Deposits are named according to their characteristic constituents, Pteropod Oozes, Globigerina Oozes, Diatom Oozes, Radiolarian Oozes, and Red Clay.

The distribution of the deep-sea deposits over the floor of the ocean is shown on the map here exhibited, but it must be remembered that there is no sharp line of demarcation between them; the Terrigenous pass gradually into the Pelagic Deposits, and the varieties of each of these great divisions also pass insensibly the one into the other, so that it is often difficult to fix the name of a given sample.

On another map here exhibited the percentage distribution of carbonate of lime in the deposits over the floor of the ocean has been represented, the results being founded on an extremely large number of analyses. The results are also shown in the following table:—

| | Sq. Geo. Miles. | Percentage. |
|---|---|---|
| Over 75% $CaCO_3$ ... | 6,000,000 | 5·8 |
| 50 to 75% ,, ... | 24,000,000 | 23·2 |
| 25 to 50% ,, ... | 14,000,000 | 13·5 |
| Under 25% ,, ... | 59,000,000 | 57·5 |
| | 103,000,000 | 100 |

The carbonate of lime shells derived from the surface play a great and puzzling *rôle* in all deep-sea deposits, varying in abundance according to the depth of the ocean and the temperature of the surface waters. In tropical regions removed from land, where the depths are less than 600 fathoms, the carbonate of lime due to the remains of these organisms from the surface may rise to 80 or 90 per cent.; with increase of depth, and under the same surface conditions, the percentage of carbonate of lime slowly diminishes, till, at depths of about 2000 fathoms, the average percentage falls to about 60, at 2400 fathoms to about 30, and at about 2600 fathoms to about 10, beyond which depth there may be only traces of carbonate of lime due to the presence of surface shells. The thin and more delicate surface shells first disappear from the deposits, the thicker and denser ones alone persist to greater depths. A careful examination of a large number of observations shows that the percentage of carbonate of lime in the deposits falls off much more rapidly at depths between 2200 and 2500 fathoms than at other depths.

The Red Clay, which occurs in all the deeper stretches of the ocean far from land, and covers nearly half of the whole sea-floor, contains—in addition to volcanic débris, clayey matter, the oxides of iron and manganese—numerous remains of whales, sharks and other fishes, together with zeolitic crystals, manganese nodules, and minute magnetic spherules, which are believed to have a cosmic origin. One hawl of a small trawl in the Central Pacific brought to the surface on one occasion, from a depth of about two and a half miles, many bushels of manganese nodules, along with fifteen hundred sharks' teeth, over fifty fragments of earbones and other bones of whales. Some of these organic remains, such as the *Carcharodon* and *Lamna* teeth and the bones of the Ziphioid whales, belong apparently to extinct species. One or two of these sharks' teeth, ear-bones, or cosmic spherules, may be occasionally found in a Globigerina Ooze, but their occurrence in this or any deposits other than Red Clay is extremely rare.

Our knowledge of the marine deposits is limited to the superficial layers; as a rule, the sounding-tube does not penetrate more than six or eight inches, but in some positions the sounding-tube and dredge have been known to sink fully two feet into the deposit. Sometimes a Red Clay is overlaid by a Globigerina Ooze, more frequently a Red Clay overlies a Globigerina Ooze, the transition between the two layers being either abrupt or gradual. In some positions it is possible to account for these layers by referring them to changes in the condition of the surface waters, but in other situations it seems necessary to call in elevations and subsidences of the sea-floor.

If the whole of the carbonate of lime shells be removed by dilute acid from a typical sample of Globigerina Ooze, the inorganic residue left behind is quite similar in composition to a typical Red Clay. This suggests that possibly, owing to some hypogene action, such as the escape of carbonic acid through the sea-floor, a deposit that once was a Globigerina Ooze might be slowly converted into a Red Clay. However, this is not the interpretation which commends itself after an examination of all the data at present available; a consideration of the rate of accumulation probably affords a more correct interpretation. It appears certain that the Terrigenous Deposits accumulate much more rapidly than the Pelagic Deposits. Among the Pelagic Deposits, the Pteropod and Globigerina Oozes of the tropical regions, being made up of the calcareous shells of a much larger number of tropical species, apparently accumulate at a greater rate than the Globigerina Oozes in extra-tropical areas. Diatom Ooze being composed of both calcareous and siliceous organisms, has again a more rapid rate of deposition than Radiolarian Ooze. In Red Clay the minimum rate of accumulation takes place. The number of sharks' teeth, of earbones and other bones of Cetaceans and of cosmic spherules in a deposit may indeed be taken as a measure of the rate of deposition. These spherules, teeth and bones are probably more abundant in the Red Clays, because few other substances there fall to the bottom to cover them up, and they thus form an appreciable part of the whole deposit. The volcanic materials in a Red Clay having, because of the slow accumulation, been for a long time exposed to the action of sea-water, have been profoundly altered. The massive manganese-iron nodules and zeolitic crystals present in the deposit are secondary products arising from the decomposition of these volcanic materials, just as the formation of glauconite, phosphatic, and calcareous and barytic nodules accompanies the decomposition of terrigenous rocks and minerals in deposits nearer continental shores. There is thus a striking difference between the average chemical and mineralogical composition of Terrigenous and Pelagic Deposits.

It would be extremely interesting to have a detailed examination of one of those deep holes where a typical Red Clay is present, and even to bore some depth into such a deposit if possible, for in these positions it is probable that not more than a few feet of deposit have accumulated since the close of the Tertiary period. One such area lies to the south-west of Australia, and its examination might possibly form part of the programme of the approaching Antarctic explorations.

### *Life on the Ocean-floor.*

It has already been stated that plant-life is limited to the shallow waters, but fishes and members of all the invertebrate groups are distributed over the floor of the ocean at all depths. The majority of these deep-sea animals live by eating the mud, clay or ooze, or by catching the minute particles of organic matter which fall from the surface. It is probably not far from the truth to say that three-fourths of the deposits now covering the floor of the ocean have passed through the alimentary canals of marine animals. These mud-eating species, many of which are of gigantic size when compared with their allies living in the shallow coastal waters, become in turn the prey of numerous rapacious animals armed with peculiar prehensile and tactile organs. Some fishes are blind, while others have very large eyes. Phosphorescent light plays a most important *rôle* in the deep sea, and is correlated with the prevailing red and brown colours of deep-sea organisms. Phosphorescent organs appear sometimes to act as a bull's-eye lantern to enable particles of

food to be picked up, and at other times as a lure or a warning. All these peculiar adaptations indicate that the struggle for life may be not much less severe in the deep sea than in the shallower waters of the ocean.

Many deep-sea animals present archaic characters; still the deep sea cannot be said to contain more remnants of faunas which flourished in remote geological periods than the shallow and fresh waters of the continents. Indeed, king-crabs, Lingulas, Trigonias, Port Jackson sharks, *Ceratodus*, *Lepidosiren*, and *Protopterus*, probably represent older faunas than anything to be found in the deep sea

Sir Wyville Thomson was of opinion that, from the Silurian period to the present day, there had been as now a continuous deep ocean with a bottom temperature oscillating about the freezing point of fresh water, and that there had always been an abyssal fauna. I incline to the view that in Palæozoic times the ocean-basins were not so deep as they are now; that the ocean then had throughout a nearly uniform high temperature, and that life was either absent or represented only by bacteria and other low forms in great depths, as is now the case in the Black Sea, where life is practically absent beyond 100 fathoms, and where the deeper waters are saturated with sulphuretted hydrogen. This is not, however, the place to enter on speculations concerning the origin of the deep-sea fauna, nor to dwell on what has been called "bipolarity" in the distribution of marine organisms.

*Evolution of the Continental and Oceanic Areas.*

I have now pointed out what appears to me to be some of the more general results arrived at in recent years regarding the present condition of the floor of the ocean. I may now be permitted to indicate the possible bearing of these results on opinions as to the origin of some fundamental geographical phenomena; for instance, on the evolution of the protruding continents and sunken ocean-basins. In dealing with such a problem much that is hypothetical must necessarily be introduced, but these speculations are based on ascertained scientific facts.

The well-known American geologist, Dutton, says: "It has been much the habit of geologists to attempt to explain the progressive elevation of plateaus and mountain platforms, and also the folding of strata, by one and the same process. I hold the two processes to be distinct, and having no necessary relation to each other. There are plicated regions which are little or not at all elevated, and there are elevated regions which are not plicated." Speaking of great regional uplifts, he says further: "What the real nature of the uplifting force may be is, to my mind, an entire mystery, but I think we may discern at least one of its attributes, and that it is a gradual expansion or a diminution of density of the subterranean magmas. . . . We know of no cause which could either add to the mass or diminish the density, yet one of the two must surely have happened. . . . Hence I infer that the cause which elevates the land involves an expansion of the underlying magmas, and the cause which depresses it is a shrinkage of the magmas; the nature of the process is at present a complete mystery." I shall endeavour to show how the detailed study of marine deposits may help to solve the mystery here referred to by Dutton.

The surface of the globe has not always been as we now see it. When, in the past, the surface had a temperature of about 400° F., what is now the water of the ocean must have existed as water vapour in the atmosphere, which would thereby—as well as because of the presence of other substances—be increased in density and volume. Life, as we know it, could not then exist. Again, science foresees a time when low temperatures, like those produced by Prof. Dewar at the Royal Institution, will prevail over the face of the earth. The hydrosphere and atmosphere will then have disappeared within the rocky crust, or the waters of the ocean will have become solid rock, and over their surface will roll an ocean of liquid air about forty feet in depth. Life, as we know it, unless it undergoes suitable secular modifications, will be extinct. Somewhere between these two indefinite points of time in the evolution of our planet it is our privilege to live, to investigate, and to speculate concerning the antecedent and future conditions of things.

When we regard our globe with the mind's eye, it appears at the present time to be formed of concentric spheres, very like, and still very unlike, the successive coats of an onion. Within is situated the vast nucleus or *centrosphere;* surrounding this is what may be called the *tektosphere* (*τηκτός*, molten), a shell of materials in a state bordering on fusion, upon which rests and creeps the *lithosphere*. Then follow *hydrosphere* and *atmosphere*, with the included *biosphere* (*βίος*, life). To the interaction of these six geospheres, through energy derived from internal and external sources, may be referred all the existing superficial phenomena of the planet.

The vast interior of the planetary mass, although not under direct observation, is known, from the results of the astronomer and physicist, to have a mean density of 5·6, or twice that of ordinary surface rock. The substances brought within the reach of observation in veinstones, in lavas, and hypogene rocks—by the action of water as a solvent and sublimant—warrant the belief that the centrosphere is largely made up of metals and metalloids with imprisoned gases. It is admitted that the vast nucleus has a very high temperature, but so enormous is the pressure of the superincumbent crust that the melting point of the substances in the interior is believed to be raised to a higher value than the temperature there existing—the centrosphere in consequence remains solid, for it may be assumed that the melting point of rock-forming materials is raised by increase of pressure. Astronomers, from a study of precession and nutation, have long been convinced that the centrosphere must be practically solid.

Recent seismological observations indicate the transmission of two types of waves through the earth—the condensational-rarefactional and the purely distortional—and the study of these tremors supports the view that the centrosphere is not only solid, but possesses great uniformity of structure. The seismological investigations of Profs. Milne and Knott point also to a fairly abrupt boundary or transition surface, where the solid nucleus passes into the somewhat plastic magma on which the firm upper crust rests.

In this plastic layer or shell—named the *tektosphere*—the materials are most probably in a state of unstable equilibrium and bordering on fusion. Here the loose textured solids of the external crust are converted into the denser solids of the nucleus or into molten masses, at a critical point of temperature and pressure; deep-seated rocks may in consequence escape through fissures in the lithosphere. Within the lithosphere itself, the temperature falls off so rapidly towards the surface as to be everywhere below the melting point of any substance there under its particular pressure.

Now, as the solid centrosphere slowly contracted from loss of heat, the primitive lithosphere, in accommodating itself—through changes in the tektosphere—to the shrinking nucleus, would be buckled, warped, and thrown into ridges. That these movements are still going on is shown by the fact that the lithosphere is everywhere and at all times in a slight but measurable state of pulsation. The rigidity of the primitive rocky crust would permit of considerable deformations of the kind here indicated. Indeed, the compression of mountain chains has most probably been brought about in this manner, but the same cannot be said of the elevation of plateaus, of mountain platforms, and of continents.

From many lines of investigation it is concluded, as we have seen, that the centrosphere is homogeneous in structure. Direct observation, on the other hand, shows that the lithosphere is heterogeneous in composition. How has this heterogeneity been brought about? The original crust was almost certainly composed of complex and stable silicates, all the silicon dioxide being in combination with bases. Lord Kelvin has pointed out that, when the solid crust began to form, it would rapidly cool over its whole surface; the precipitation of water would accelerate this process, and there would soon be an approximation to present conditions. As time went on the plastic or critical layer—the tektosphere—immediately beneath the crust would gradually sink deeper and deeper, while ruptures and re-adjustments would become less and less frequent than in earlier stages. With the first fall of rain the silicates of the crust would be attacked by water and carbon dioxide, which can at low temperatures displace silicon dioxide from its combinations. The silicates, in consequence, have been continuously robbed of a part, or the whole of their bases. The silica thus set free goes ultimately to form quartz veins and quartz sand on or about the emerged land, while the bases leached out of the disintegrating rocks are carried out into the ocean and ocean-basins. A continuous disintegration and differentiation of materials of the lithosphere, accompanied by a sort of migration and selection among mineral substances, is thus always in progress. Through the agency of life, carbonate of lime accumulates

in one place; through the agency of winds, quartz sand is heaped up in another; through the agency of water, beds of clay, of oxides of iron and of manganese are spread out in other directions.

The contraction of the centrosphere supplies the force which folds and crumples the lithosphere. The combined effect of hydrosphere, atmosphere and biosphere on the lithosphere gives direction and a determinate mode of action to that force. From the earliest geological times the most resistant dust of the continents has been strewn along the marginal belt of the sea-floor skirting the land. At the present time, the deposits over this area contain on the average about 70 per cent. of free and combined silica, mostly in the form of quartz sand. In the abysmal deposits far from land there is an average of only about 30 per cent. of silica, and hardly any of this in the form of quartz sand. Lime, iron and the other bases largely predominate in these abysmal regions. The continuous loading on the margins of the emerged land by deposits tends by increased pressure to keep the materials of the tektosphere in a solid condition immediately beneath the loaded area. The unloading of emerged land tends by relief of pressure to produce a viscous condition of the tektosphere immediately beneath the denuded surfaces. Under the influence of the continuous shakings, tremors and tremblings always taking place in the lithosphere, the materials of the tektosphere yield to the stresses acting on them, and the deep-seated portions of the terrigenous deposits are slowly carried towards, over or underneath the emerged land. The rocks subsequently re-formed beneath continental areas out of these terrigenous materials, under great pressure and in hydrothermal conditions, would be more acid than the rocks from which they were originally derived, and it is well known that the acid silicates have a lower specific gravity than the intermediate or basic ones. By a continual repetition of this process the continental protuberances have been gradually built up of lighter materials than the other parts of the lithosphere. The relatively light quartz, which is also the most refractory, the most stable and the least fusible among rock-forming minerals, plays in all this the principal *rôle*. The average height of the surface of the continents is about three miles above the average level of the abysmal regions. If now we assume the average density of the crust beneath the continents to be 2·5, and of the part beneath the abysmal regions to be 3, then the spheroidal surface of equal pressure—the tektosphere—would have a minimum depth of eighteen miles beneath the continents and fifteen miles beneath the oceans, or if we assume the density of the crust beneath the continents to be 2·5, and beneath the abysmal regions to be 2·8, then the tektosphere would be twenty-eight miles beneath the continents and twenty-five miles beneath the oceans. The present condition of the earth's crust might be brought about by the disintegration of a quantity of quartz-free volcanic rock, covering the continental areas to a depth of eighteen miles, and the re-formation of rocks out of the disintegrated materials.

Where the lighter and more bulky substances have accumulated there has been a relative increase of volume, and in consequence bulging has taken place at the surface over the continental areas. Where the denser materials have been laid down there has been flattening, and in consequence a depression of the abysmal regions of the ocean-basins. It is known that, as a general rule, where large masses of sediment have been deposited, their deposition has been accompanied by a depression of the area. On the other hand, where broad mountain platforms have been subjected to extensive erosion, the loss of altitude by denudation has been made good by a rise of the platform. This points to a movement of matter on to the continental areas.

If this be anything like a true conception of the interactions that are taking place between the various geospheres of which our globe is made up, then we can understand why, in the gradual evolution of the surface features, the average level of the continental plains now stands permanently about three miles above the average level of those plains which form the floor of the deep ocean-basins. We may also understand how the defect of mass under continents and an excess of mass under the oceans have been brought about, as well as deficiency of mass under mountains and excess of mass under plains. Even the local anomalies indicated by the plumb-line, gravity and magnetic observations may in this way receive a rational explanation. It has been urged that an enormous time—greater even than what is demanded by Darwin—would be necessary for an evolution of the existing surface features on these lines. I do not think so. Indeed, in all that relates to geological time I agree, generally speaking, with the physicists rather than with the biologists and geologists.

### *Progress of Oceanic Research.*

I have now touched on some of the problems and speculations suggested by recent deep-sea explorations; and there are many others, equally attractive, to which no reference has been made. It is abundantly evident that, for the satisfactory explanation of many marine phenomena, further observations and explorations are necessary. Happily there is no sign that the interest in oceanographical work has in any way slackened. On the contrary, the number of scientific men and ships engaged in the study of the ocean is rapidly increasing. Among all civilised peoples and in all quarters of the globe the economic importance of many of the problems that await solution is clearly recognised.

We have every reason to be proud of the work continually carried on by the officers and ships attached to the Hydrographic Department of the British Navy. They have surveyed coasts in all parts of the world for the purposes of navigation, and within the past few years have greatly enlarged our knowledge of the sea-bed and deeper waters over wide stretches of the Pacific and other oceans. The samples of the bottom which are procured, being always carefully preserved by the officers, have enabled very definite notions to be formed as to the geographical and bathymetrical distribution of marine deposits.

The ships belonging to the various British telegraph cable companies have done most excellent work in this as well as in other directions. Even during the present year Mr. R. E. Peake has in the s.s. *Britannia* procured 477 deep soundings in the North Atlantic, besides a large collection of deep-sea deposits, and many deep-sea temperature and current observations.

The French have been extending the valuable work of the *Talisman* and *Travailleur*, while the Prince of Monaco is at the present moment carrying on his oceanic investigations in the Arctic Seas with a large new yacht elaborately and specially fitted out for such work. The Russians have recently been engaged in the scientific exploration of the Black Sea and the Caspian Sea, and a special ship is now employed in the investigation of the Arctic fisheries of the Murman coast under the direction of Prof. Knipowitsch. Admiral Makaroff has this summer been hammering his way through Arctic ice, and at the same time carrying on a great variety of systematic observations and experiments on board the *Yermak*—the most powerful and most effective instrument of marine research ever constructed. Mr. Alexander Agassiz has this year recommenced his deep-sea explorations in the Pacific on board the U.S. steamer *Albatross*. He proposes to cross the Pacific in several directions, and to conduct investigations among the Paumotu and other coral island groups. Prof. Weber is similarly employed on board a Dutch man-of-war in the East Indian Seas. The Deutsche Seewarte at Hamburg, under the direction of Dr. Neumayer, continues its praiseworthy assistance and encouragement to all investigators of the ocean, and this year the important German Deep-Sea Expedition, in the s.s. *Valdivia*, arrived home after most successful oceanographical explorations in the Atlantic, Indian and Great Southern Oceans.

The *Belgica* has returned to Europe safely with a wealth of geological and biological collections and physical observations, after spending, for the first time on record, a whole winter among the icefields and icebergs of the Antarctic. Mr. Borchgrevink in December last again penetrated to Cape Adare, successfully landed his party at that point and is now wintering on the Antarctic continent. The expeditions of Lieut. Peary, of Prof. Nathorst, of Captain Sverdrup, and of the Duke of Abruzzi, which are now in progress, may be expected to yield much new information about the condition of the Arctic Ocean. Mr. Wellman has just returned from the north of Franz Josef Land with observations of considerable interest.

Some of the scientific results obtained by the expeditions in the Danish steamer *Ingolf* have lately been published, and these, along with the results of the joint work pursued for many years by the Swedes, Danes and Norwegians, may ultimately have great economic value from their direct bearing on fishery problems and on weather forecasting over long periods of time.

Largely through the influence of Prof. Otto Pettersson, an International Conference assembled at Stockholm a few months ago, for the purpose of deliberating as to a programme of conjoint scientific work in the North Sea and northern parts of the Atlantic, with special reference to the economic aspect of sea-fisheries. A programme was successfully drawn up, and an organisation suggested for carrying it into effect: these proposals are now under the consideration of the several States. The Norwegian Government has voted a large sum of money for building a special vessel to conduct marine investigations of the nature recommended by this conference. It is to be hoped the other North Sea Powers may soon follow this excellent example.

The various marine stations and laboratories for scientific research in all parts of the world furnish each year much new knowledge concerning the ocean. Among our own people the excellent work carried on by the Marine Biological Association, the Irish Fisheries Department, the Scottish Fishery Board, the Lancashire Fisheries Committee, the Cape and Canadian Fisheries Departments, is well worthy of recognition and continued support. Mr. George Murray, Mr. H. N. Dickson, Prof. Cleve, Prof. Otto Pettersson, Mr. Robert Irvine and others have, with the assistance of the officers of the Mercantile Marine, accumulated in recent years a vast amount of information regarding the distribution of temperature and salinity, as well as of the planktonic organisms at the surface of the ocean. The papers by Mr. H. C. Russell on the icebergs and currents of the Great Southern Ocean, and of Mr. F. W. Walker on the density of the water in the Southern Hemisphere, show that the Australian Colonies are taking a practical interest in oceanographical problems.

*Proposed Antarctic Explorations.*

The great event of the year, from a geographical point of view, is the progress that has been made towards the realisation of a scheme for the thorough scientific exploration in the near future of the whole South Polar region. The British and German Governments have voted or guaranteed large sums of money to assist in promoting this object, and princely donations have likewise been received from private individuals, in this connection the action of Mr. L. W. Longstaff in making a gift of 25,000*l.*, and of Mr. A. C. Harmsworth in promising 5000*l.*, being beyond all praise.

There is an earnest desire among the scientific men of Britain and Germany that there should be some sort of co-operation with regard to the scientific work of the two expeditions, and that these should both sail in 1901, so that the invaluable gain attaching to simultaneous observations may be secured. Beyond this nothing has, as yet, been definitely settled. The members of the Association will presently have an opportunity of expressing their opinions as to what should be attempted by the British expedition, how the work in connection with it should be arranged, and how the various researches in view can best be carried to a successful issue.

I have long taken a deep interest in Antarctic exploration, because such exploration must necessarily deal largely with oceanographical problems, and also because I have had the privilege of studying the conditions of the ocean within both the Arctic and Antarctic circles. In the year 1886 I published an article on the subject of Antarctic Exploration in the *Scottish Geographical Magazine*. This article led to an interesting interview, especially when viewed in the light of after events, for, a few weeks after it appeared in type, a young Norwegian walked into the *Challenger* office in Edinburgh to ask when the proposed expedition would probably start, and if there were any chance of his services being accepted. His name was Nansen.

When at the request of the President I addressed the Royal Geographical Society on the same subject in the year 1893, I made the following statement as to what it seemed to me should be the general character of the proposed exploration: "A dash at the South Pole is not, however, what I advocate, nor do I believe *that* is what British science at the present time desires. It demands rather a steady, continuous, laborious and systematic exploration of the whole southern region with all the appliances of the modern investigator." At the same time I urged further, that these explorations should be undertaken by the Royal Navy in two ships, and that the work should extend over two winters and three summers.

This scheme must now be abandoned, so far at least as the Royal Navy is concerned, for the Government has intimated that it can spare neither ships nor officers, men nor money, for an undertaking of such magnitude. The example of Foreign Powers—rather than the representations from our own scientific men—appears to have been chiefly instrumental in at last inducing the Government to promise a sum of 45,000*l.*, provided that an equal amount be forthcoming from other sources. This resolve throws the responsibility for the financial administration, for the equipment and for the management of this exploration on the representative scientific societies, which have no organisation ready for carrying out important executive work on such an extensive scale. I am doubtful whether this state of matters should be regarded as a sign of increasing lukewarmness on the part of the Government towards marine research, or should rather be looked on as a most unexpected and welcome recognition of the growing importance of science and scientific men to the affairs of the nation. Let us adopt the latter view, and accept the heavy responsibility attached thereto.

Any one who will take the trouble to read, in the *Proceedings* of the Royal Society of London, the account of the discussion which recently took place on "The Scientific Advantages of an Antarctic Expedition," will gather some idea of the number and wide range of the subjects which it is urged should be investigated within the Antarctic area; the proposed researches have to do with almost every branch of science. Unless an earnest attempt be made to approach very near to the ideal there sketched out, widespread and lasting disappointment will certainly be felt among the scientific men of this country. The proposed expedition should not be one of adventure. Not a rapid invasion and a sudden retreat, with tales of hardships and risks, but a scientific occupation of the unknown area by observation and experiment should be aimed at in these days.

I have all along estimated the cost of a well-equipped Antarctic expedition at about 150,000*l.* I see no reason for changing my views on this point at the present time, nor on the general scope of the work to be undertaken by the proposed expedition, as set forth in the papers I have published on the subject. There is now a sum of at most 90,000*l.* in hand, or in view. If one ship should be specially built for penetrating the icy region, and be sent south with one naturalist on board, then such an expedition may, it will be granted, bring back interesting and important results. But it must be distinctly understood that this is not the kind of exploration scientific men have been urging on the British public for the past fifteen or twenty years. We must, if possible, have two ships, with landing parties for stations on shore, and with a recognised scientific leader and staff on board of each ship. Although we cannot have the Royal Navy, these ships can be most efficiently officered and manned from the Mercantile Marine. With only one ship many of the proposed observations would have to be cut out of the programme. In anticipation of this being the case, there are at the present moment irreconcilable differences of opinion among those most interested in these explorations, as to which sciences must be sacrificed.

The difficulties which at present surround this undertaking are fundamentally those of money. These difficulties would at once disappear, and others would certainly be overcome, should the members of the British Association at this meeting agree to place in the hands of their President a sum of 50,000*l.*, so that the total amount available for Antarctic exploration would become something like 150,000*l.* Although there is but one central Government, surely there are within the bounds of this great Empire two more men like Mr. Longstaff. The Government has suddenly placed the burden of upholding the high traditions of Great Britain in marine research and exploration on the shoulders of her scientific men. In their name I appeal to all our well-to-do fellow-countrymen in every walk of life for assistance, so that these new duties may be discharged in a manner worthy of the Empire and of the well-earned reputation of British Science.

## SECTION G.

### MECHANICAL SCIENCE.

OPENING ADDRESS BY SIR WILLIAM WHITE, K.C.B., LL.D., F.R.S., PRESIDENT OF THE SECTION.

IN this Address it is proposed to review briefly the characteristic features of the progress made in steam navigation; to glance at the principal causes of advance in the speeds of steamships and in the lengths of the voyages on which such vessels

can be successfully employed; and to indicate how the experience and achievement of the last sixty years bear upon the prospects of further advance.

There is reason to hope that this choice of subject is not inappropriate. From the beginning of steam navigation the British Association in its corporate capacity, by the appointment of special committees, and by the action of individual members, has greatly assisted the scientific treatment of steamship design. Valuable contributions bearing on the resistance offered by water to the motion of ships, the conduct and analysis of the results of steamship trials, the efficiency of propellers and cognate subjects have been published in the Reports of the Association. Many of these have largely influenced practice, and most of them may be claimed as the work of this Section.

On this occasion no attempt will be made either to summarise or appraise the work that has been done. It must suffice to mention the names of three men to whom naval architects are deeply indebted, and whose labours are ended—Scott Russell, Rankine, and William Froude. Each of them did good work, but to Froude we owe the device and application of the method of model experiment with ships and propellers, by means of which the design of vessels of novel types and unprecedented speeds can now be undertaken with greater confidence than heretofore.

As speeds increase, each succeeding step in the ascending scale becomes more difficult, and the rate of increase in the power to be developed rapidly augments. Looking back on what has been achieved, it is impossible to overrate the courage and skill displayed by the pioneers of steam navigation, who had at first to face the unknown, and always to depend almost entirely on experience gained with actual ships, when they undertook the production of swifter vessels. Their successors of the present day have equal need to make a thorough study of the performances of steamships both in smooth water and at sea. In many ways they have to face greater difficulties than their predecessors, as ships increase in size and speed. On the other hand, they have the accumulated experience of sixty years to draw upon, the benefit of improved methods of trials of steamships, the advantage of scientific procedure in the record and analysis of such trials and the assistance of model experiments.

Steamship design to be successful must always be based on experiment and experience as well as on scientific principles and processes. It involves problems of endless variety and great complexity. The services to be performed by steamships differ in character, and demand the production of many distinct types of ships and propelling apparatus. In all these types, however, there is one common requirement—the attainment of a specified speed. And in all types there has been a continuous demand for higher speed.

Stated broadly, the task set before the naval architect in the design of any steamship is to fulfil certain conditions of speed in a ship which shall not merely carry fuel sufficient to traverse a specified distance at that speed, but which shall carry a specified load on a limited draught of water. Speed, load, power and fuel supply are all related; the two last have to be determined in each case. In some instances other limiting conditions are imposed affecting length, breadth or depth. In all cases there are three separate efficiencies to be considered: those of the ship as influenced by her form; of the propelling apparatus, including the generation of steam in the boilers and its utilisation in the engines; and of the propellers. Besides these considerations, the designer has to take account of the materials and structural arrangements which will best secure the association of lightness with strength in the hull of the vessel. He must select those types of engines and boilers best adapted for the service proposed. Here the choice must be influenced by the length of the voyage, as well as the exposure it may involve to storm and stress. Obviously the conditions to be fulfilled in an ocean-going passenger steamer of the highest speed, and in a cross-Channel steamer designed to make short runs at high speed in comparatively sheltered waters, must be radically different. And so must be the conditions in a swift sea-going cruiser of large size and great coal endurance, from those best adapted for a torpedo boat or destroyer. There is, in fact, no general rule applicable to all classes of steamships: each must be considered and dealt with independently, in the light of the latest experience and improvements. For merchant ships there is always the commercial consideration—Will it pay? For warships there is the corresponding inquiry—Will the cost be justified by the fighting power and efficiency?

*Characteristics of Progress in Steam Navigation.*

Looking at the results so far attained, it may be said that progress in steam navigation has been marked by the following characteristics:—

(1) Growth in dimensions and weights of ships, and large increase in engine-power, as speeds have been raised.

(2) Improvements in marine engineering accompanying increase of steam pressure. Economy of fuel and reduction in the weight of propelling apparatus in proportion to the power developed.

(3) Improvements in the materials used in shipbuilding; better structural arrangements; relatively lighter hulls and larger carrying power.

(4) Improvements in form, leading to diminished resistance and economy of power expended in propulsion.

These general statements represent well-known facts—so familiar, indeed, that their full significance is often overlooked. It would be easy to multiply illustrations, but only a few representative cases will be taken.

*Transatlantic Passenger Steamers.*

The Transatlantic service naturally comes first. It is a simple case, in that the distance to be covered has remained practically the same, and that for most of the swift passenger steamers cargo-carrying capacity is not a very important factor in the design.

In 1840 the Cunard steamship *Britannia*, built of wood, propelled by paddle-wheels, maintained a sea-speed of about 8½ knots. Her steam pressure was 12 lbs. per square inch. She was 207 feet long, about 2000 tons in displacement, her engines developed about 750 horse-power, and her coal consumption was about 40 tons per day, nearly 5 lbs. of coal per indicated horse-power per hour. She had a full spread of sail.

In 1871 the White Star steamship *Oceanic* (first of that name) occupied a leading position. She was iron-built, propelled by a screw, and maintained a sea-speed of about 14½ knots. The steam pressure was 65 lbs. per square inch, and the engines were on the compound principle. She was 420 feet long, about 7200 tons in displacement, her engines developed 3000 horse-power, and she burnt about 65 tons of coal per day, or about 2 lbs. per indicated horse-power per hour. She carried a considerable spread of sail.

In 1889 the White Star steamer *Teutonic* appeared, propelled by twin screws and practically with no sail-power. She is steel-built, and maintains a sea-speed of about 20 knots. The steam pressure is 180 lbs. per square inch, and the engines are on the triple expansion principle. She is about 565 feet long, 16,000 tons displacement, 17,000 horse-power indicated, with a coal consumption of about 300 tons a day, or from 1·6 to 1·7 lbs. per indicated horse-power per hour.

In 1894 the Cunard steamship *Campania* began her service, with triple expansion engines, twin screws and no sail-power. She is about 600 feet long, 20,000 tons displacement, develops about 28,000 horse-power at full speed of 22 knots, and burns about 500 tons of coal per day.

The new *Oceanic*, of the White Star Line, is just beginning her work. She is of still larger dimensions, being 685 feet in length and over 25,000 tons displacement. From the authoritative statements made, it appears that she is not intended to exceed 22 knots in speed, and that the increase in size is to be largely utilised in additional carrying power.

The latest German steamers for the Transatlantic service are also notable. A speed of 22½ knots has been maintained by the *Kaiser Wilhelm der Grosse*, which is 25 feet longer than the *Campania*. Two still larger steamers are now building. The *Deutschland* is 660 feet long and 23,000 tons displacement; her engines are to be of 33,000 horse-power, and it is estimated she will average 23 knots. The other vessel is said to be 700 feet long, and her engines are to develop 36,000 horse-power, giving an estimated speed of 23½ knots. All these vessels have steel hulls and twin screws. It will be noted that to gain about three knots an hour nearly 50 per cent. will have been added to the displacement of the *Teutonic*, the engine-power and coal consumption will be doubled, and the cost increased proportionately.

Sixty years of continuous effort and strenuous competition on this great "ocean ferry" may be summarised in the following statement. Speed has been increased from 8½ to 22½ knots; the time on the voyage has been reduced to about 38 per cent.

of what it was in 1840. Ships have been more than trebled in length, about doubled in breadth, and increased tenfold in displacement. The number of passengers carried by a steamship has been increased from about 100 to nearly 2000. The engine-power has been made forty times as great. The ratio of horse-power to the weight driven has been increased fourfold. The rate of coal consumption (measured per horse-power per hour) is now only about one-third what it was in 1840. To drive 2000 tons weight across the Atlantic at a speed of $8\frac{1}{2}$ knots, about 550 tons of coal were then burnt: now, to drive 20,000 tons across at 22 knots, about 3000 tons of coal are burnt. With the low pressure of steam and heavy slow-moving paddle-engines of 1840, each ton weight of machinery, boilers, &c., produced only about 2 horse-power for continuous working at sea. With modern twin-screw engines and high steam pressure, each ton weight of propelling apparatus produces from 6 to 7 horse-power. Had the old rate of coal consumption continued, instead of 3000 tons of coal, 9000 tons would have been required for a voyage at 22 knots. Had the engines been proportionately as heavy as those in use sixty years ago, they would have weighed about 14,000 tons. In other words, machinery, boilers, and coals would have exceeded in weight the total weight of the *Campania* as she floats to-day. There could not be a more striking illustration than this of the close relation between improvements in marine engineering and the development of steam navigation at high speeds.

Equally true is it that this development could not have been accomplished but for the use of improved materials and structural arrangements. Wood, as the principal material for the hulls of high-powered swift steamers, imposed limits upon dimensions, proportions and powers which would have been a bar to progress. The use of iron, and later of steel, removed those limits. The percentage of the total displacement devoted to hull in a modern Atlantic liner of the largest size is not much greater than was the corresponding percentage in the wood-built *Britannia* of 1840, of one-third the length and one-tenth the total weight.

Nor must it be overlooked that with increase in dimensions have come considerable improvements in *form*, favouring economy in propulsion. This is distinct from the economy resulting from increase in *size*, which Brunel appreciated thoroughly half a century ago when he designed the *Great Britain* and the *Great Eastern*. The importance of a due relation between the lengths of the "entrance and run" of steamships and their intended maximum speeds, and the advantages of greater length and fineness of form as speeds are increased, were strongly insisted upon by Scott Russell and Froude. Naval architects, as a matter of course, now act upon the principle, so far as other conditions permit. For it must never be forgotten that economy of propulsion is only one of many desiderata which must be kept in view in steamship design. Structural weight and strength, seaworthiness and stability, all claim attention, and may necessitate modifications in dimensions and form which do not favour the maximum economy of propulsion.

### *Swift Passenger Steamers for Long Voyages.*

Changes similar to those described for the Transatlantic service have been in progress on all the great lines of ocean traffic. In many instances increase in size has been due, not only to increase in speed, but to enlarged carrying power and the extension of the lengths of voyages. No distance is now found too great for the successful working of steamships, and the sailing fleet is rapidly diminishing in importance. So far as long-distance steaming is concerned, the most potent factor has undoubtedly been the marvellous economy of fuel that has resulted from higher steam pressures and greater expansion. In all cases, however, advances have been made possible, not merely by economy of fuel, but by improvements in form, structure and propelling apparatus, and by increased dimensions.

Did time permit, this might be illustrated by many interesting facts drawn from the records of the great steamship companies which perform the services to the Far East, Australia, South America, and the Pacific. As this is not possible, I must be content with a brief statement regarding the development of the fleet of the Peninsular and Oriental Company.

The paddle steamer *William Fawcett* of 1829 was about 75 feet long, 200 tons displacement, of 60 nominal horse-power (probably about 120 indicated horse-power), and in favourable weather steamed at a speed of 8 knots. Her hul was of wood, and, like all the steamers of that date, she had considerable sail-power.

In 1853 the *Himalaya* iron-built screw steamer of this line was described as "of larger dimensions than any then afloat, and of extraordinary speed." She was about 340 feet long, over 4000 tons load displacement, 2000 indicated horse-power on trial, with an average sea-speed of about 12 knots. The steam pressure was 14 lbs. per square inch, and the daily coal consumption about 70 tons. This vessel was transferred to the Royal Navy and did good service as a troopship for forty years.

In 1893 another *Himalaya* was added to the company's fleet. She was steel-built, nearly 470 feet long and 12,000 tons load displacement, with over 8000 indicated horse-power and a capability to sustain 17 to 18 knots at sea, on a daily consumption of about 140 tons of coal. The steam pressure is 160 lbs. per square inch, and the engines are of the triple expansion type.

Comparing the two *Himayalas*, it will be seen that in forty years the length has been increased about 40 per cent., displacement trebled, horse-power quadrupled and speed increased about 50 per cent. The proportion of horse-power to displacement has only been increased as three to four, enlarged dimensions having secured relative economy in propulsion. The rate of coal consumption has been probably reduced to about one-third of that in the earlier ship

The latest steamers of the line are of still larger dimensions, being 500 feet long and of proportionately greater displacement. It is stated that the *Himalaya* of 1853 cost 132,000*l.* complete for sea: the corresponding outlay on her successors is not published, but it is probably twice as great.

On the service to the Cape similar developments have taken place. Forty years ago vessels less than 200 feet long and about 7 knots performed the service, whereas the latest additions to the fleets exceed 500 feet in length, and can, if required, be driven at 17 to 18 knots, ranking in size and power next to the great Transantlaotic liners.

Commercial considerations necessarily regulate what is undertaken in the construction of merchant steamers, including the swift vessels employed in the conveyance of passengers and mails. The investment of 600,000*l.* to 700,000*l.* in a single vessel like a great Transatlantic liner is obviously a serious matter for private owners; and even the investment of half that amount in a steamer of less dimensions and speed is not to be lightly undertaken. It is a significant fact that, whereas fifteen years ago nearly all the largest and swiftest ocean steamers were British built and owned, at the present time there is serious competition in this class by German, American and French companies. It is alleged that this change has resulted from the relatively large subsidies paid by foreign Governments to the owners of swift steamers; and that British owners, being handicapped in this way, cannot continue the competition in size and speed on equal terms unless similarly assisted. This is not the place to enter into any discussion of such matters, but they obviously involve greater considerations than the profit of shipowners, and have a bearing on the naval defence of the Empire. In 1887 the Government recognised this fact, and made arrangements for the subvention and armament of a number of the best mercantile steamships for use as auxiliary cruisers. Since then other nations have adopted the policy, and given such encouragement to their shipowners that the numbers of swift steamers suitable for employment as cruisers have been largely increased. Not long since the First Lord of the Admiralty announced to Parliament that the whole subject was again under consideration.

### *Cargo and Passenger Steamers.*

Cargo steamers, no less than passenger steamers, have been affected by the improvements mentioned. Remarkable developments have occurred recently, not merely in the purely cargo-carrier, but in the construction of vessels of large size and good speed carrying very great weights of cargo and considerable numbers of passengers. The much-decried "ocean-tramp" of the present day exceeds in speed the passenger and mail steamer of fifty years ago. Within ten years vessels in which cargo-carrying is the chief element of commercial success have been increased in length from 300 or 400 feet to 500 or 600 feet; in gross register tonnage from 5000 to over 13,000 tons; and in speed from 10 or 12 knots to 15 or 16 knots. Vessels are now building for the Atlantic service which can carry 12,000 to 13,000 tons deadweight, in addition

to passengers, while possessing a sea-speed as high as that of the swiftest mail steamers afloat in 1880. Other vessels of large carrying power and good speed are running on much longer voyages, such as to the Cape and Australia. In order to work these ships successfully very complete organisation is necessary for the collection, embarkation and discharge of cargo. The enterprise and skill of shipowners have proved equal to this new departure, as they have in all other developments of steamships.

How much further progress will be made in the sizes and speeds of these mixed cargo and passenger steamers cannot be foreseen. The limits will be fixed by commercial considerations, and not by the capability of the shipbuilder.

In passing, it may be noted that while the lengths and breadths of steamships have been greatly increased, there has been but a moderate increase in draught. Draught of water is, of course, practically determined by the depths available in the ports and docks frequented, or in the Suez Canal for vessels trading to the East. From the naval architect's point of view, increase in draught is most desirable as favouring increase of carrying power and economy of propulsion. This fact has been strongly represented by shipowners and ship-designers, and not without result. The responsible authorities of many of the principal ports and of the Suez Canal have taken action towards giving greater depth.

Other changes have become necessary on the part of dock and port authorities in consequence of the progress made in shipbuilding. Docks and dock-entrances have had to be increased in size, more powerful lifting appliances provided and large expenditure incurred. There is no escape from these changes if the trade of a port is to be maintained. The chief lesson to be learnt from past experience is that when works of this character are planned it is wise to provide a large margin beyond the requirements of existing ships.

*Cross-Channel Steamers.*

The conditions to be fulfilled in vessels designed to steam at high speed for limited periods differ essentially from those holding good in ocean-going steamers. None the less interest attaches, however, to cross-Channel steamers, and in no class has more notable progress been made. It is much to be desired that at this meeting some competent authority should have presented to the Association an epitome of the history of the steam packet service between Dover and the continent. I cannot attempt it. So far as I am informed, the first steamer was placed on this route in 1821, was of 90 tons burden, 30 horse-power nominal, and maintained a speed of 7 to 8 knots. She was built by Denny of Dumbarton, engined by David Napier and named the *Rob Roy*. It is interesting to note that the lineal successors of the builder of this pioneer vessel have produced some of the most recent and swiftest additions to the cross-Channel service.

In 1861–2 a notable advance was made by the building of vessels which were then remarkable for structure and speed, although small and slow when compared with vessels now running. Their designers realised that lightness of hull was of supreme importance, and with great trouble and expense obtained steel of suitable quality. The machinery was of special design and relatively light for the power developed. A small weight of coal and cargo had to be carried, and the draught of water was kept to about 7 feet. Under then existing conditions it was a veritable triumph to attain speeds of 15 to 16 knots in vessels only 190 feet long, less than 25 feet broad, and under 350 tons in displacement. To raise the trial speed to 20 or 21 knots in later vessels performing the same service, whose design includes the improvements of a quarter of a century, it has been found necessary to adopt lengths exceeding 320 feet and breadths of about 35 feet, with engines developing 4500 to 6000 indicated horse-power, and with very great increase in coal consumption and cost. On other cross-Channel services between Dover and the continent still larger and more powerful paddle-steamers are employed.

Another interesting contrast is to be found in the comparison of the steamers running between Holyhead and Kingstown in 1860 and at the present time. The *Leinster* of 1860 was 328 feet long, 35 feet broad and rather less than 13 feet draught. Her trial displacement was under 2000 tons and with 4750 horse-power she made $17\frac{3}{4}$ knots. She had a steam pressure of 25 lbs. per square inch and was propelled by paddle-wheels driven by slow-moving engines of long stroke. Her successor of 1896 is about 30 feet greater length, $6\frac{1}{2}$ feet greater breadth and about 10 per cent. greater displacement. The steam pressure is 170 lbs. per square inch. Forced draught is used in the stokeholds. Twin screws are adopted, driven by quick-running vertical engines of the triple expansion type. Very great economy of coal consumption is thus secured as compared with the earlier vessel, and much lighter propelling apparatus in proportion to the power, which is from 8000 to 9000 horse-power at the full speed of 23 knots. The hull is built of steel, and is proportionately lighter.

This is a typical case, and illustrates the effect of improvements in shipbuilding and engineering in thirty-five years. The later ship probably requires to carry no greater load of coal than, if so great as, her predecessor, although her engine-power is nearly double. The weight devoted to propelling machinery and boilers is probably not so great. Thanks to the use of steel instead of iron, and to improved structural arrangements, the weight of hull is reduced in comparison with dimensions, and a longer ship is produced better adapted to the higher speed. Messrs. Laird of Birkenhead, who built three of the *Leinster* class forty years ago, and have built all the new vessels, are to be congratulated on their complete success.

Between such vessels designed for short runs at high speed and requiring therefore to carry little coal, while the load carried exclusive of coal is trifling, and an ocean-going steamer of the same average speed designed to make passages of 3000 miles, there can obviously be little in common. But equal technical skill is required to secure the efficient performance of both services. In the cross-Channel vessel, running from port to port, and under constant observation, conditions of working in engine and boiler rooms, as well as relative lightness in scantlings of hull, can be accepted which would be impossible of application in a sea-going ship. These circumstances in association with the small load carried explain the apparent gain in speed of the smaller vessel in relation to her dimensions.

*Increase in Size and Speed of Warships.*

Turning from sea-going ships of the mercantile marine to warships, one finds equally notable facts in regard to increase in speed, associated with enlargement in dimensions and advance in propelling apparatus, materials of construction, structural arrangements and form.

Up to 1860 a measured-mile speed of 12 to 13 knots was considered sufficient for battleships and the largest classes of cruisers. All these vessels possessed good sail-power and used it freely as an auxiliary to steam, or as an alternative when cruising or making passages.

When armoured battleships were built (1859) the speeds on measured-mile trials were raised to 14 or $14\frac{1}{2}$ knots, and so remained for about twenty years. Since 1880 the speeds of battleships have been gradually increased, and in the latest types the measured-mile speed required is 19 knots.

Up to 1870 the corresponding speeds in cruisers ranged from 15 to 16 knots. Ten years later the maximum speeds were 18 to $18\frac{1}{2}$ knots in a few vessels. Since then trial speeds of 20 to 23 knots have been attained or are contemplated.

There is, of course, a radical distinction between these measured-mile performances of warships and the average sea-speeds of merchant steamers above described. But for purposes of comparison between warships of different dates, measured mile trials may fairly be taken as the standard. For long-distance steaming the power developed would necessarily be much below that obtained for short periods and with everything at its best. This is frankly recognised by all who are conversant with the warship design, and fully allowed for in estimates of sea-speeds. On the other hand, it is possible to point to sea trials made with recent types where relatively high speeds have been maintained for long periods. For example, the battleship *Royal Sovereign* has maintained an average speed of 15 knots from Plymouth to Gibraltar, and the *Renown* has maintained an equal speed from Bermuda to Spithead. As instances of good steaming by cruisers, reference may be made to 60-hour trials with the *Terrible* when she averaged over 20 knots, and to the run home from Gibraltar to the Nore by the *Diadem* when she exceeded 19 knots. Vessels of the *Pelorus* class of only 2100 tons displacement have made long runs at sea averaging over 17 knots. Results such as these represent a substantial advance in speed of Her Majesty's ships in recent years.

Similar progress has been made in foreign warships built abroad as well as in this country. It is not proposed to give

any facts for these vessels, or to compare them with results obtained by similar classes of ships in the Royal Navy. Apart from full knowledge of the conditions under which speed trials are made, a mere statement of speeds attained is of no service. One requires to be informed accurately respecting the duration of the trial, the manner in which engines and boilers are worked, the extent to which boilers are "forced," or the proportion of heating surface to power indicated, the care taken to eliminate the influence of tide or current, the mode in which the observations of speed are made, and other details, before any fair or exact comparison is possible between ships. For present purposes, therefore, it is preferable to confine the illustrations of increase in speed in warships to results obtained under Admiralty conditions, and which are fairly comparable.

A great increase in size has accompanied this increase in speed, but it has resulted from other changes in modern types, as well as from the rise in speed. Modern battleships are of 13,000 to 15,000 tons, and modern cruisers of 10,000 to 14,000 tons, not merely because they are faster than their predecessors, but because they have greater powers of offence and defence and possess greater coal endurance. Only a detailed analysis, which cannot now be attempted, could show what is the actual influence of these several changes upon size and cost, and how greatly the improvements made in marine engineering and shipbuilding have tended to keep down the growth in dimensions consequent on increase in load carried, speed attained, and distance traversed.

It will be noted also that, large as are the dimensions of many classes of modern warships, they are all smaller in length and displacement than the largest mercantile steamers above described. There is no doubt a popular belief that the contrary is true, and that warships exceed merchant ships in tonnage. This arises from the fact that merchant ships are ordinarily described, not by their displacement tonnage, but by their "registered tonnage," which is far less than their displacement. As a matter of fact, the largest battleships are only of about two-thirds the displacement of the largest passenger steamers, and from 200 to 300 feet shorter. The largest cruisers are from 100 to 200 feet shorter than the largest passenger steamers, and about 60 per cent. of their displacement. In breadth the warships exceed the largest merchant steamers by 5 to 10 feet. This difference in form and proportions is the result of radical differences in the vertical distribution of weights carried, and is essential to the proper stability of the warships. Here we find an illustration of the general principle underlying all ship-designing. In selecting the forms and proportions of a new ship, considerations of economical propulsion cannot stand alone. They must be associated with other considerations, such as stability, protection and manœuvring power, and in the final result economy of propulsion may have to be sacrificed, to some extent, in order to secure other essential qualities.

### *Advantages of Increased Dimensions.*

Before passing on, it may be interesting to illustrate the gain in economy of propulsion resulting from increase in dimensions by means of the following table, which gives particulars of a number of typical cruisers, all of comparatively recent design :

| — | No. 1 | No. 2 | No. 3 | No. 4 | No. 5 |
|---|---|---|---|---|---|
| Length (feet) ... .. | 280 | 300 | 360 | 435 | 500 |
| Breadth (feet) ... ... | 35 | 43 | 60 | 69 | 71 |
| Mean draught (feet) ... | 13 | 16½ | 23¾ | 24½ | 26¼ |
| Displacement (tons) .. | 1800 | 3400 | 7,400 | 11,000 | 14,200 |
| Indicated horse-power for 20 knots .. ... . | 6000 | 9000 | 11,000 | 14,000 | 15,500 |
| Indicated horse-power per ton of displacement ... | 3·33 | 2·65 | 1·48 | 1·27 | 1·09 |

The figures given are the results of actual trials, and embody therefore the efficiencies of propelling machinery, propellers and forms of the individual ships. Even so they are instructive. Comparing the first and last, for example, it will be seen that, while the displacement is increased nearly *eightfold*, the power for 20 knots is only increased about 2·6 times. If the same types of engines and boilers had been adopted in these two vessels—which was not the case, of course—the weights of propelling apparatus and coal for a given distance would have been proportional to the respective powers ; that is to say, the larger vessel would have been equipped with only 2·6 times the weight carried by the smaller. On the other hand, roughly speaking, the *disposable weights*, after providing for hulls and fittings in these two vessels, might be considered to be proportional to their displacements. As a matter of fact, this assumption is distinctly in favour of the smaller ship. Adopting it, the larger vessel would have about *eight* times the disposable weight of the smaller ; while the demand for propelling apparatus and fuel would be only *2·6 times* that of the smaller vessel. There would therefore be an enormous margin of carrying power in comparison with displacement in the larger vessel. This might be devoted, and in fact was devoted, partly to the attainment of a speed considerably exceeding 20 knots (which was a maximum for the smaller vessel), partly to increased coal endurance and partly to protection and armament.

Another interesting comparison may be made between vessels Nos. 4 and 5 in the preceding table, by tracing the growth in power necessary to drive the vessels at speeds ranging from 10 knots up to 22 knots.

| | No. 4 | No. 5 |
|---|---|---|
| 10 knots ... | 1,500-horse-power | 1,800-horse-power |
| 12 ,, ... | 2,500 ,, ,, | 3,100 ,, ,, |
| 14 ,, ... | 4.000 ,, ,, | 5,000 ,, ,, |
| 16 ,, ... | 6,000 ,, ,, | 7,500 ,, ,, |
| 18 ,, ... | 9,000 ,, ,, | 11,000 ,, ,, |
| 20 ,, ... | 14,000 ,, ,, | 15,500 ,, ,, |
| 22 ,, ... | 23,000 ,, ,, | 23,000 ,, ,, |

It will be noted that up to the speed of 18 knots there is a fairly constant ratio between the powers required to drive the two ships. As the speeds are increased the larger ship gains, and at 22 knots the same power is required in both ships. The smaller vessel, as a matter of fact, was designed for a maximum speed of 20½ knots, and the larger for 22 knots. Unless other qualities had been sacrificed, neither space nor weight could have been found in the smaller vessel for machinery and coals corresponding to 22 knots. The figures are interesting, however, as illustrations of the principle that economy of propulsion is favoured by increase in dimensions as speeds are raised.

Going a step further, it may be assumed that in unsheathed cruisers of this class about 40 per cent. of the displacement will be required for the hull and fittings, so that the balance or "disposable weight" would be about 60 per cent. ; say 6600 tons for the smaller vessel, and 8500 tons for the larger, a gain of nearly 2000 tons for the latter. If the speed of 22 knots were secured in both ships, with machinery and boilers of the same type, the larger ship would therefore have about 2000 tons greater weight available for coals, armament, armour and equipment.

These illustrations of well-known principles have been given simply for the assistance of those not familiar with the subject, and they need not be carried further. More general treatment of the subject, based on experimental and theoretical investigation, will be found in text-books of naval architecture, but would be out of place in this Address.

### *Swift Torpedo Vessels.*

Torpedo flotillas are comparatively recent additions to war fleets. The first torpedo boat was built by Mr. Thornycroft for the Norwegian Navy in 1873, and the same gentleman built the first torpedo boat for the Royal Navy in 1877. The construction of the larger class, known as "torpedo-boat destroyers," dates from 1893. These various classes furnish some of the most notable examples extant of the attainment of extraordinarily high speeds, for short periods and in smooth water, by vessels of small dimensions. Their qualities and performances, therefore, merit examination.

Mr. Thornycroft may justly be considered the pioneer in this class of work. Greatly impressed by the combination of lightness and power embodied in railway locomotives, Mr. Thornycroft applied similar principles to the propulsion of small boats, and obtained remarkably high speeds. His work became more widely known when the results were published of a series of trials conducted in 1872 by Sir Frederick Bramwell on a small

vessel named the *Miranda*. She was only 45 feet long and weighed 4 tons, yet she exceeded 16 knots on trial. The Norwegian torpedo boat built in 1873 was 57 feet long, $7\frac{1}{2}$ tons, and of 15 knots; the first English torpedo boat of 1877 was 81 feet long, 29 tons and attained $18\frac{1}{2}$ knots.

Mr. Yarrow also undertook the construction of small swift vessels at a very early date, and has greatly distinguished himself throughout the development of the torpedo flotilla. Messrs. White, of Cowes, previously well known as builders of steamboats for use on board ships, extended their operations to the construction of torpedo boats. These three firms for a considerable time practically monopolised this special class of work in this country. Abroad they had able competitors in Normand in France, Schichau in Germany, and Herreshoff in the United States. Keen competition led to successive improvements and rapid rise in speed. During the last six years the demand for a fleet of about 100 destroyers, to be built in the shortest possible time, involved the necessity for increasing the sources of supply. At the invitation of the Admiralty, a considerable number of the leading shipbuilding and engineering firms have undertaken and successfully carried through the construction of destroyers varying from 26 to 33 knots in speed, although the work was necessarily of a novel character, involving many difficulties.

As the speeds of torpedo vessels have risen, so have their dimensions increased. Within the class the law shown to hold good in larger vessels applies equally. In 1877 a first-class torpedo boat was 81 feet long, under 30 tons weight, developed 400-horse-power, and steamed $18\frac{1}{2}$ knots. Ten years later the corresponding class of boat was 135 feet long, 125 tons weight, developed 1500 horse-power and steamed 23 knots. In 1897 it had grown to 150 feet in length, 140 to 150 tons, 2000 horse-power and 26 knots.

Destroyers are not yet of seven years' standing, but they come under the rule. The first examples (1893) were 180 feet long, 240 tons, 4000 horse-power and 26 to 27 knots. They were followed by 30-knot vessels, 200 to 210 feet long, 280 to 300 tons, 5500 to 6000 horse-power. Vessels now in construction are to attain 32 to 33 knots, their lengths being about 230 feet, displacements 360 to 380 tons and engine-power 8000 to 10,000 horse-power.

Cost has gone up with size and power, and the limit of progress in this direction will probably be fixed by financial considerations, rather than by constructive difficulties, great as these become as speeds rise.

It may be interesting to summarise the distinctive features of torpedo-vessel design.

(1) The propelling apparatus is excessively light in proportion to the maximum power developed. Water-tube boilers are now universally adopted, and on speed trials they are "forced" to a considerable extent. High steam pressures are used. The engines are run at a high rate of revolution—often at 400 revolutions per minute. Great care is taken in every detail to economise weight. Speed trials at maximum power only extend over three hours. On such trials in a destroyer each ton weight of propelling apparatus produces about 45 indicated horse-power. Some idea of the relative lightness of the destroyer's machinery and boilers will be obtained when it is stated that in a large modern cruiser with water-tube boilers, high steam pressure, and quick-running engines, the maximum power obtained on an eight hours' trial corresponds to about 12 indicated horse-power per ton of engines, boilers, &c. That is to say, the proportion of power to weight of propelling apparatus is from three and a half to four times as great in the destroyer as it is in the cruiser.

(2) A very large percentage of the total weight (or displacement) of a torpedo vessel is assigned to propelling apparatus. In a destroyer of 30 knots trial-speed, nearly one-half the total weight is devoted to machinery, boilers, &c. In the swiftest cruisers of large size the corresponding allocation of weight is less than 20 per cent. of the displacement, and in the largest and fastest mail steamers it is about 20 to 25 per cent.

(3) The torpedo vessel carries a relatively small load of fuel, equipment, &c. Taking a 30-knot destroyer, for example, the speed trials are made with a load not exceeding 12 to 14 per cent. of the displacement. In a swift cruiser the corresponding load would be from 40 to 45 per cent., or proportionately more than three times as great. What this difference means may be illustrated by two statements. If the load in a destroyer were trebled and the vessel correspondingly increased in draught and weight, the speed attained with the same maximum power would be about three knots less. If, on the other hand, the vessel were designed to attain 30 knots on trial with the heavier load, her displacement would probably be increased about 70 to 80 per cent.

(4) The hull and fittings of the torpedo vessel are exceedingly light in relation to the dimensions and engine-power. For many parts of the structure steel of high-tensile strength is used. Throughout, the utmost care is taken to economise weight. In small vessels, for special service, many conditions can be accepted which would be inadmissible in larger sea-going vessels. The result of all this care is the production of hull-structures having ample *general* strength for their special service. Lightness of scantling, of course, involves small *local* strength against collision, grounding and other accident. Experience proves, however, that this involves no serious risk or difficulty.

These conditions are essential to the attainment of very high speeds for short periods. They resemble the conditions ruling the design of cross-Channel steamers, so far as relative lightness of propelling apparatus, small load and light scantlings are concerned. The essential differences lie in the requirements for passenger accommodation as compared with the requirements for armament of the torpedo vessel. No one has yet proposed to extend the torpedo-vessel system to sea-going ships of large dimensions. Very similar conditions for the propelling apparatus have been accepted in a few cruisers of considerable dimensions, wherein high speeds for short periods were required. It is, however, unquestionable that in many ways, and particularly in regard to machinery design, the construction of torpedo vessels has greatly influenced that of larger ships.

One important consideration must not be overlooked. For short-distance steaming at high speeds economy in coal consumption is of little practical importance, and it is all-important to secure lightness of propelling apparatus in relation to power. For long-distance steaming, on the contrary, economy in coal consumption is of primary importance; and savings in weight of propelling apparatus, even of considerable amount, may be undesirable if they involve increased coal consumption. Differences of opinion prevail as to the real economy of fuel obtainable with boilers and engines such as are fitted in torpedo vessels. Claims are made for some vessels which represent remarkable economy. Only enlarged experience can settle these questions.

Endurance is also an important quality in sea-going ships of large size, not merely in structures, but in propelling apparatus. The extreme lightness essential in torpedo vessels obviously does not favour endurance if high powers are frequently or continuously required. Still, it cannot be denied that the results obtained in torpedo vessels show such a wide departure from those usual in sea-going ships as to suggest the possibility of some intermediate type of propelling apparatus applicable to large sea-going ships and securing sufficient durability and economy of fuel in association with further savings of weight.

### *The Parsons Turbo-Motor.*

The steam turbo-motor introduced by Mr. Charles Parsons is to be described by the inventor during these meetings; but it is impossible for me to pass it over in this review without a brief notice. This rotary engine, with its very high rate of revolution, reduces the weights of machinery, shafting and propellers greatly below the weight required in the quickest-running engines of the reciprocating type. This reduction in the proportion of weight to power carries with it, of course, the possibility of higher speed in a vessel of given dimensions; and when large powers are employed the absolute gain is very great. An illustration of this has been given by Mr. Parsons in the *Turbinia*. That remarkable vessel is 100 feet long and of $44\frac{1}{2}$ tons displacement, but she has attained 33 to 34 knots in short runs. There are three shafts, each carrying three screw propellers, each shaft driven by a steam turbine making over 2000 revolutions at full speed, when more than 2000-horse-power is developed. A water-tube boiler of special design supplies steam of 175 lbs. pressure, and is exceptionally light for the steam produced, being highly forced. The whole weight of machinery and boilers is 22 tons; in other words, about 100 horse-power (indicated) is produced for each ton weight of propelling apparatus. This is rather more than twice the proportion of power to weight as compared with the lightest machinery and boilers fitted in torpedo boats and destroyers. It will be noted that in the *Turbinia*, as in the destroyers, about half the total weight is devoted to propelling apparatus; and in both instances the load carried is relatively small. The secret

of the extraordinary speed is to be found in the extreme lightness of propelling apparatus and small load.

No doubt in the *Turbinia* lightness has been pushed further than it would be in vessels of larger size and greater power. In such vessels a lower rate of revolution would probably be accepted, additional motors would be fitted for manœuvring and going astern, boilers of relatively greater weight would be adopted and other changes made. But, after making ample allowance for all such increases in weight, it is unquestionable that considerable economies must be possible with rotary engines. Two other vessels of the destroyer type with turbo-motors (one for the Royal Navy) are now approaching completion. Their trials will be of great interest, as they will furnish a direct comparison with vessels of similar size and form, fitted with similar boilers and driven by reciprocating engines.

On the side of coal consumption, Mr. Parsons claims at least equality with the best triple expansion engines. Into the other advantages attending the use of rotary engines it is not necessary now to enter.

Reference must be made, however, to one matter in which Mr. Parsons has done valuable and original work. In torpedo vessels of high speed the choice of the most efficient propellers has always been a matter of difficulty, and the solution of the problem has in many instances involved extensive experimental trials. By means of alterations in propellers alone, very large increases in speed have been effected; and even now there are difficulties to be faced. When Mr. Parsons adopted the extraordinary speed of revolution just named for the *Turbinia*, he went far beyond all experience and precedent and had to face unknown conditions. He has found the solution, after much patient and original investigation, in the use of multiple screws of small diameter. His results in this direction are of general interest to all who have to deal with screw propulsion.

Such radical changes in propelling machinery as are involved in the adoption of turbo-motors must necessarily be subjected to thorough test before they will be widely adopted. The experiment which the Admiralty are making is not on a small scale as regards power. Although it is made in a destroyer, about 10,000 horse-power will probably be developed and a correspondingly high speed attained. It may well happen that from this experiment very far-reaching effects may follow. Mr. Parsons himself has prepared many designs illustrating various applications of the system to sea-going, cross-Channel and special service vessels. Where shallowmess of draught is unavoidable, the small diameter of the screws possible with the quick-running turbines is clearly an important matter.

*Comparisons between Large and Small Vessels.*

It has been shown that the attainment of very high speeds by vessels of small size involves many conditions not applicable to large sea-going steamships. But it is equally true that in many ways the trials of small swift vessels constitute model experiments from which interesting information may be obtained as to what would be involved in driving ships of large size at speeds much exceeding any of which we have experience. When the progressive steam-trials of such small vessels can be studied side by side with experiments made on models to determine their resistance at various speeds, then the fullest information is obtained and the best guide to progress secured. This advantage, as has been said, we owe to William Froude.

His contributions to the Reports of the British Association are classics in the literature of the resistance and propulsion of ships. In 1874 he practically exhausted the subject of frictional resistance so far as it is known; and his Presidential Address to this Section in 1875 dealt fully and lucidly with the modern or stream-line theory of resistance. No doubt there would be advantage in extending Froude's experiments on frictional resistance to greater lengths and to ship-shaped forms. It is probable also that dynamometric determinations of the resistance experienced by ships of modern forms and considerable size when towed at various speeds would be of value if they could be conducted. These extensions of what Froude accomplished are not easily carried out; and in this country the pressure of work on shipbuilding for the Royal Navy has, for many years past, taxed to the utmost limits the capacity of the Admiralty experimental establishment so ably superintended by Mr. R. E. Froude, allowing little scope for purely scientific investigations, and making it difficult to deal with the numerous experiments incidental to the designs of actual ships. Now that Holland, Russia, Italy and the United States have equipped experimental establishments, while Germany and France are taking steps in that direction, we may hope for extensions of purely scientific work and additions to our knowledge. In this direction, however, I am bound to say that much might be done if experimental establishments capable of dealing with questions of a general nature relating to resistance and propulsion were added to the equipment of some of our universities and colleges. Engineering laboratories have been multiplied, but there is as yet no example of a model experimental tank devoted to instruction and research.

It is impossible, and possibly is unnecessary, to attempt in this Address any account of Froude's "scale of comparison" between ships and models at "corresponding speeds." But it may be of interest to give a few illustrations of the working of this method, in the form of a contrast between a destroyer of 300 tons, 212 feet long, capable of steaming 30 knots an hour, and a vessel of similar form enlarged to 765 feet in length and 14,100 tons. The ratio of dimensions is here about 3·61 : 1; the ratio of displacements is 47 : 1; and the ratio of corresponding speeds is 1·9 : 1.

To 12 knots in the small vessel would correspond 22·8 knots in the large vessel; and the resistance experienced by the large vessel at 22·8 knots (neglecting a correction for friction) should be forty-seven times that of the small vessel at 12 knots. By experiment, this resistance for the small vessel was found to be 1·8 tons. Hence, for the large vessel at 22·8 knots the resistance should be 84·6 tons. This would correspond to an "effective horse-power" of over 13,000, or to about 26,000 indicated horse-power. The frictional correction would reduce this to about 25,000 horse-power, or about 1·8 horse-power per ton. Now turning to the destroyer, it is found experimentally that at 22·8 knots she experiences a resistance of about 11 tons, corresponding to an effective horse-power of over 1700, and an indicated horse-power of about 3000: say 10 horse-power per ton, or nearly five and a half times the power per ton required in the larger vessel. This illustrates the economy of propulsion arising from increased dimensions.

Applying the same process to a speed of 30 knots in the large ship, the corresponding speed in the small ship is 15·8 knots. Her resistance at that speed is experimentally determined to be 3·5 tons, and the resistance of the large ship at 30 knots (neglecting frictional correction) is about 165 tons. The effective horse-power of the large ship at 30 knots is, therefore, about 34,000, corresponding to 68,000 horse-power indicated. Allowing for the frictional correction, this would drop to about 62,000 horse-power, or 4·4 horse-power per ton. For the destroyer at 30 knots the resistance is about $17\frac{1}{2}$ tons; the effective horse-power is 3600, and the indicated horse-power about 6000, or 20 horse-power per ton, nearly five times as great as the corresponding power for the large ship. But while the destroyer under her trial conditions actually reaches 30 knots, it is certain that in the large ship neither weight nor space could be found for machinery and boilers of the power required for 30 knots, and of the types usually adopted in large cruisers, in association with an adequate supply of fuel. The explanation of the methods by which the high speed is reached in the destroyer has already been given. Her propelling apparatus is about one-fourth as heavy in relation to its maximum power, and her load is only about one-third as great in relation to the displacement, when compared with the corresponding features in a swift modern cruiser.

It will, of course, be understood that in practice, under existing conditions, a cruiser of 14,000 tons would not be made 765 feet long, but probably about 500 feet. The hypothetical cruiser has been introduced simply for purposes of comparison with the destroyer.

The earlier theories of resistance assumed that the resistance experienced by ships varied as the square of the speed. We now know that the frictional resistances of clean-painted surfaces of considerable length vary as the 1·83 power of the speed. This seems a small difference, but it is sensible in its effects, causing a reduction of 32 per cent. at 10 knots, nearly 40 per cent. at 20 knots, and 42 per cent. at 25 knots. On the other hand, it is now known that the laws of variation of the residual or wave-making resistance may depart very widely from the law of the square of the speed, and it may be interesting to trace for the typical destroyer how the resistance actually varies.

Take first the *total resistance*. Up to 11 knots it varies nearly as the square of the speed; at 16 knots it has reached

the cube; from 18 to 20 knots it varies as the 3·3 power. Then the index begins to diminish: at 22 knots it is 2·7; at 25 knots it has fallen to the square, and from thence to 30 knots it varies, practically, as does the frictional resistance.

The residual resistance varies as the square of the speed up to 11 knots, as the cube at 12½ to 13 knots, as the fourth power about 14½ knots, and at a higher rate than the fifth power at 18 knots. Then the index begins to fall, reaching the square at 24 knots, and falling still lower at higher speeds.

It will be seen, therefore, that when this small vessel has been driven up to 24 or 25 knots by a large relative expenditure of power, further increments of speed are obtained with less proportionate additions to the power.

Passing from the destroyer to the cruiser of similar form but of 14,100 tons, and once more applying the "scale of comparison," it will be seen that to 25 knots in the destroyer corresponds a speed of 47½ knots in the large vessel. In other words, the cruiser would not reach the condition where further increments of speed are obtained with comparatively moderate additions of power until she exceeded 47 knots, which is an impossible speed for such a vessel under existing conditions. The highest speeds that could be reached by the cruiser with propelling apparatus of the lightest type yet fitted in large sea-going ships would correspond to speeds in the destroyer, for which the resistance is varying as the highest power of the speed. These are suggestive facts.

Frictional resistance, as is well known, is a most important matter in all classes of ships and at all speeds. Even in the typical destroyer this is so. At 12 knots the friction with clean-painted bottom represents 80 per cent. of the total resistance; at 16 knots 70 per cent; at 20 knots a little less than 50 per cent.; and at 30 knots 45 per cent. If the coefficient of friction were doubled and the maximum power developed with equal efficiency, a loss of speed of fully 4 knots would result.

In the cruiser of similar form the friction represents 90 per cent. at 12 knots, 85 per cent. at 16 knots, nearly 80 per cent. at 20 knots, and over 70 per cent. at 23 knots. If the coefficient of friction were doubled at 23 knots and the corresponding power developed with equal efficiency, the loss of speed would approximate to 4 knots.

These illustrations only confirm general experience that clean bottoms are essential to economical propulsion and the maintenance of speed, and that frequent docking is necessary in vessels with bare iron or steel skins, which foul in a comparatively short time.

### *Possibilities of further Increase in Speed.*

From the facts above mentioned it is obvious that the increase in speed which has been effected is the result of many improvements, and has been accompanied by large additions to size, engine-power and cost. These facts do not discourage the "inventor," who finds a favourite field of operation in schemes for attaining speeds of 50 to 60 knots at sea in vessels of moderate size. Sometimes the key to this remarkable advance is found in devices for reducing surface-friction by the use of wonderful lubricants to be applied to the wetted surfaces of ships, or by interposing a layer of air between the skins of ships and the surrounding water, or other departures from ordinary practice. If these gentlemen would "condescend to figures," their estimates, or guesses, would be less sanguine. In many cases the proposals made would fail to produce any sensible reduction in resistance; in others they would increase resistance.

Other proposals rest upon the idea that resistance may be largely reduced by adopting novel forms, departing widely from ordinary ship shapes. Very often small-scale experiments, made in an unscientific and inaccurate manner, are adduced as proofs of the advantages claimed. In other instances mere assertion is thought sufficient. Ordinarily no regard is had to other considerations, such as internal capacity, structural weight and strength, stability and seaworthiness. Most of these proposals do not merit serious consideration. Any which seem worth investigation can be dealt with simply and effectively by the method of model experiments. A striking example of this method will be found in the unusual form of a Parliamentary Paper (No. 313, of 1873), containing a report made by Mr. William Froude to the Admiralty. Those interested in the subject will find therein much matter of special interest in connection with the conditions attending abnormally high speeds. It must suffice now to say that ship shaped forms are not likely to be superseded at present.

The most prolific "inventions" are those connected with supposed improvements in propellers. One constantly meets with schemes guaranteed by the proposers to give largely increased efficiency and corresponding additions to speed. Variations in the numbers and forms of screws or paddles, the use of jets of water or air expelled by special apparatus through suitable openings, the employment of explosives, imitations of the fins of fishes and numberless other departures from established practice are constantly being proposed. As a rule the "inventors" have no intimate knowledge of the subject they treat, which is confessedly one of great difficulty. When experiments are adduced in support of proposals they are almost always found to be inconclusive and inaccurate. More or less mathematical demonstrations find favour with other inventors, but they are not more satisfactory than the experiments. An air of great precision commonly pervades the statements made as to possible increase in efficiency or speed. I have known cases where probable speeds with novel propellers have been estimated (or guessed) to the third place of decimals. In one such instance a trial was made with the new propeller, with the result that instead of a gain in efficiency there was a serious loss of speed. Very few of the proposals made have merit enough to be subjected to trial. None of them can possibly give the benefits claimed.

It need hardly be added that in speaking thus of so-called "inventors" there is no suggestion that improvement has reached its limit, or that further discovery is not to be made. On the contrary, in regard to the forms of ships and propellers, continuous investigation is proceeding and successive advances are being made. From the nature of the case, however, the difficulties to be surmounted increase as speeds rise; and a thorough mastery of the past history and present condition of the problems of steamship design and propulsion is required as a preparation for fruitful work in the nature of further advance.

It would be idle to attempt any prediction as to the characteristic features of ocean navigation sixty years hence. Radical changes may well be made within that period. Confining attention to the immediate future, it seems probable that the lines of advance which I have endeavoured to indicate will remain in use. Further reductions may be anticipated in the weight of propelling apparatus and fuel in proportion to the power developed; further savings in the weight of the hulls, arising from the use of stronger materials and improved structural arrangements; improvements in form; and enlargement in dimensions. If greater draughts of water can be made possible, so much the better for carrying power and speed. For merchant vessels commercial considerations must govern the final decision; for warships the needs of naval warfare will prevail. It is certain that scientific methods of procedure and the use of model experiments on ships and propellers will become of increased importance.

Already avenues for further progress are being opened. For example, the use of water-tube boilers in recent cruisers and battleships of the Royal Navy has resulted in saving *one-third* of the weight necessary with cylindrical boilers of the ordinary type to obtain the same power, with natural draught in the stokeholds. Differences of opinion prevail, no doubt, as to the policy of adopting particular types of water-tube boilers; but the weight of opinion is distinctly in favour of some type of water-tube boiler in association with the high steam pressures now in use. Greater safety, quicker steam-raising and other advantages, as well as economy of weight, can thus be secured. Some types of water-tube boilers would give greater saving in weight than the particular type used in the foregoing comparison with cylindrical boilers.

Differences of opinion prevail also as to the upper limit of steam pressure which can with advantage be used, taking into account all the conditions in both engines and boilers. From the nature of the case, increases in pressure beyond the 160 to 180 lbs. per square inch commonly reached with cylindrical boilers cannot have anything like the same effect upon economy of fuel as the corresponding increases have had, starting from a lower pressure. Some authorities do not favour any excess above 250 lbs. per square inch on the boilers; others would go as high as 300 lbs., and some still higher.

Passing to the engine-rooms, the use of higher steam-pressures and greater rates of revolution may, and probably will, produce reductions in weight compared with power. The use of stronger materials, improved designs, better balance of the moving parts, and close attention to details have tended in the

same direction without sacrifice of strength. Necessarily there must be a sufficient margin to secure both strength and endurance in the motive power of steamships. Existing arrangements are the outgrowth of large experience, and new departures must be carefully scrutinised.

The use of rotary engines, of which Mr. Parsons' turbo-motor is the leading example at present, gives the prospect of further economies of weight. Mr. Parsons is disposed to think that he could about halve the weights now required for the engines, shafting, and propellers of an Atlantic liner while securing proper strength and durability If this could be done in association with the use of water-tube boilers it would effect a revolution in the design of this class of vessel, permitting higher speeds to be reached without exceeding the dimensions of existing ships.

It does not appear probable that, with coal as the fuel, water-tube boilers will surpass in economy the cylindrical hoilers now in use; and skilled stoking seems essential if water-tube boilers are to be equal to the other type in rate of coal consumption. The general principle holds good that as more perfect mechanical appliances are introduced, so more skilled and disciplined management is required in order that the full benefits may be obtained. In all steamship performance the "human factor" is of great importance, but its importance increases as the appliances become more complex. In engine-rooms the fact has been recognised and the want met. There is no reason why it should not be similarly dealt with in the boiler-rooms.

Liquid fuel is already substituted for coal in many steamships. When sufficient quantities can be obtained it has many obvious advantages over coal, reducing greatly manual labour in embarking supplies, conveying it to the boilers and using it as fuel. Possibly its advocates have claimed for it greater economical advantages over coal than can be supported by the results of extended experiment. Even if the saving in weight for equal evaporation is put as low as 30 per cent. of the corresponding weight of coal, it would amount to 1000 tons on a first-class Atlantic liner. This saving might be utilised in greater power and higher speed, or in increased load. There would be a substantial saving on the stokehold staff. At present it does not appear that adequate supplies of liquid fuel are available. Competent authorities here and abroad are giving attention to this question, and to the development of supplies. If the want can be met at prices justifying the use of liquid fuel, there will undoubtedly be a movement in that direction.

Stronger materials for the construction of hulls are already available. They are, however, as yet but little used, except for special classes of vessels. Mild steel has taken the place of iron, and effected considerable savings of weight. Alloys of steel with nickel and other metals are now made which give strength and rigidity much superior to mild steel, in association with ample ductility. For destroyers and torpedo boats this stronger material is now largely used. It has also been adopted for certain important parts of the structures of recent ships in the Royal Navy. Of course the stronger material is more costly, but its use enables sensible economies of weight to be made. It has been estimated, for example, that in an Atlantic liner of 20 knots average speed about 1000 tons could be saved by using nickel steel instead of mild steel. This saving would suffice to raise the average speed more than a knot, without varying the dimensions of the ship.

Alloys of aluminium have also been used for the hulls or portions of the hulls of yachts, torpedo-boats, and small vessels. Considerable savings in weight have thus been effected. On the other hand, these alloys have been seriously corroded when exposed to the action of sea-water, and on that account are not likely to be extensively used. Other alloys will probably be found which will be free from this defect, and yet unite lightness with strength to a remarkable degree.

Other examples might be given of the fact that the metallurgist has by no means exhausted his resources, and that the shipbuilder may look to him for continued help in the struggle to reduce the weights of floating structures.

It is unnecessary to amplify what has already been said as to possible increase in the efficiency and types of propellers. With limited draught, as speeds increase and greater powers have to be utilised, multiple propellers will probably come into use. Mr. Parsons has shown how such problems may be dealt with; and other investigators have done valuable work in the same direction.

In view of what has happened and is still happening, it is practically certain that the dimensions of steamships have not yet attained a maximum.

Thanks to mechanical appliances, the largest ships built or to be built can be readily steered and worked. In this particular difficulties have diminished in recent years, notwithstanding the great growth in dimensions.

Increase in length and weight favour the better maintenance of speed at sea. The tendency, therefore, will be to even greater regularity of service than at present. Quicker passages will to some extent diminish risks, and the chance of breakdown will be lessened if multiple propellers are used. Even now, with twin screws, the risk of total breakdown is extremely small.

Whatever may be the size and power of steamships, there must come times at sea when they must slow down and wait for better weather. But the larger and longer the vessel, the fewer will be the occasions when this precaution need be exercised.

It must never be forgotten that as ships grow in size, speed, and cost, so the responsibilities of those in charge increase. The captain of a modern steamship needs remarkable qualities to perform his multifarious duties efficiently. The chief engineer must have great powers of organisation, as well as good technical knowledge, to control and utilise most advantageously the men and machinery in his charge. Apart from the ceaseless care, watchfulness and skill of officers and men, the finest ships and most perfect machinery are of little avail. The "human factor" is often forgotten, but is all-important. Let us hope that in the future, as in the past, as responsibilities increase so will the men be found to bear them.

## *NOTES.*

A STATUE, erected in memory of the late M. F. Tisserand, will be unveiled at Nuits-Saint-Georges on October 15.

MAJOR RONALD ROSS has sent Mr. A. L. Jones a letter from Sierra Leone on his investigations into the cause of malaria. In the course of the communication he says:—We have now practically finished our work here. We have found—(*a*) that local species of Anopheles (mosquitoes) carry malaria; (*b*) that these species breed in a few stagnant puddles. For many scientific reasons we have come to the conclusion that the truly malarial fever is caused here solely by the mosquito—probably entirely by the Anopheles species. We estimate then that most of the malarial fever here can be got rid of at almost no cost except of a little energy on the part of the local authorities.

A SUCCESSION of earthquake shocks occurred on Monday night, September 25, in the district of Darjeeling, involving great loss of life and damage to property. No details as to the exact times of the shocks have been received. The earthquake was accompanied by a remarkable rainfall, and was followed by extensive landslips. It is reported that in twenty-four hours over 20 inches of rain fell, and in all 28 inches fell in thirty-eight hours.

THE associate editorship of the *American Journal of Science*, vacant by the death of Prof. Marsh, has been taken up by Prof. L. V. Pirsson, of Yale College.

IN a report just issued on metalliferous mines in the North Wales district, Dr. C. Le Neve Foster refers to the fact that several foreign companies have lately purchased mines in that district with the object of reworking them. He remarks:—"Though I welcome the advent into Wales of the famous Vieille Montagne Company, for I have hopes that its methods of mining and dressing will form useful object-lessons to us, I am not blind to the slur which is cast upon us as a mining nation. If such a capable body of commercial men as the directors of the Vieille Montagne Company propose to resuscitate some of our abandoned mines, it may be taken for granted that they consider the enterprise as likely to be profitable. Is our mining talent so far behind the times that foreigners can make a profit out of mines which we have abandoned as worthless? If so, the

technical skill of continental mining engineers is of a higher nature than that of our own people, and we are not keeping pace with the times. It therefore behoves us as a nation to get out of the groove of the slovenly old-fashioned methods of working ore mines, which linger so long in this country, and to give our mining superintendents and mining foremen such technical training as will render them at least the equals of their continental competitors." It is to be hoped that this note of warning will lead British mining companies to make use of the resources which modern science has placed at their disposal.

THE *Journal* of the Society of Arts announces that among the prizes offered by the French Société d'Encouragement pour l'Industrie Nationale, open to all the world except members of the administrative council, and to be awarded next year, are the following :—Two thousand francs (80*l.*) for a publication useful to the chemical or metallurgical industry, a treatise on metallurgical chemistry summarising the works that have appeared on the subject during the last twenty years being invited ; two prizes of 500 francs (20*l.*) each for scientific chemical researches the results of which are useful to industry, the authors not being required to have realised the practical applications which they may foresee as resulting from their observations ; 2000 francs (80*l.*) for the scientific study of an industrial process the theory of which is still imperfectly known, the methods that permit of obtaining a given result being often known long before the nature of the phenomena is suspected, and yet the knowledge of which has great interest as regards reducing the number of empirical trials necessary for realising fresh improvements ; and 3000 francs (120*l.*) for the production of permanent magnets, the qualities expected from which are power and stability. The models, papers, descriptions, &c., must be sent in before December 31 to the Secretary of the Société d'Encouragement, 44 Rue de Rennes, Paris.

THE death is announced of Mr. Edward Case, the author of a paper on "The Dymchurch Wall and Reclamation of Romney Marsh," read at the recent meeting of the British Association. For many years Mr. Case was a superintending engineer in the Public Works Department in Ceylon. Of late he gained distinction in the engineering world by his investigations of the problem of sea defence, and by the results which he had obtained on a variety of shores.

THE Funafuti Boring Expedition has very recently led to the rectification of a common ethnographical error, and the discovery of an interesting fact in zoo-geography. In the Monograph on the Atoll of Funafuti published by the Australian Museum, Sydney (part iii. 1897, p. 199) Mr. E. R. Waite referred to a large undetermined fish known to the natives as "Palu," and to traders as "Oil-fish." According to Mr. Louis Becke, a full-grown Palu would weigh up to 150 lbs. and be 6 feet long ; the average size is about 3 or 4 feet, and weight 40 to 60 lbs. The natives have many superstitions in regard to Palu ; every portion of it is edible, even the head and bones when cooked turning into a rich mass of jelly. The flesh of the Palu, if left uncooked, never putrefies ; it simply dissolves into a colourless and odourless oil. Perhaps the great regard the natives have for it is due to the fact of its being a rapid and powerful purgative. It is a deep-water fish, and is usually caught at a depth of from 120 fathoms down to 200 fathoms ; the fishing is only done at night. The Palu fishing-hook has been described by Mr. C. Hedley (*l.c.* part iv., 1897, p. 272), who points out that this large hook, which is widely distributed in the Central Pacific, and may be seen in most ethnographical collections, has been described by all authors as a "shark-hook." The last expedition to Funafuti has been fortunate enough to obtain a specimen of this fish, and in an appendix (part ix., 1899, p. 539) Mr. Waite has solved the riddle, and found that this mysterious fish is the well-known *Ruvettus pretiosus*, which hitherto was known only from the North Atlantic, and whose recorded range is now enormously increased. The Escolar (Atlantic name) has been taken at depths as great as 300 and 400 fathoms, but can be taken only at night in September and the early part of October.

WE learn from the September number of *Annalen der Hydrographie* that the Deutsche Seewarte, in conjunction with the Berlin Meteorological Office, proposes to issue a ten-day report, containing values of barometric pressure, air-temperature and rainfall for, say, one hundred stations between the west coast of North America and the east coast of Asia, accompanied by a map showing observations taken on board German ships traversing the North Atlantic. The report would be issued as a supplement to the *Daily Weather Bulletin*, about twenty days after date. The success of the proposal will to a great extent depend upon the willingness of other countries to furnish ten-day means for some selected stations in their respective systems.

WE have received from Dr. W. Doberck, Government Astronomer, Hong Kong Observatory, his annual report for 1898. The "Observations and Researches" contain synopses of fifteen years' meteorological and magnetic observations and a number of very useful tables relating to the climatology of the Colony.

THE papers read at the ninth annual general meeting of the Museums Association, held in Sheffield in July of last year, are contained in the "Report of Proceedings," just published by Messrs. Dulau and Co. All the subjects dealt with are of interest to every one concerned in museum work, among them being : the relation of museums to elementary education ; the arrangement of museum herbaria, the electric light installation at the Manchester Museum, the exhibition of museum specimens, the mounting of marine animals as transparencies for museum purposes, the ethnological arrangement of archæological material, and some Russian museums. Mr. Herbert Bolton, the editor of the volume, calls attention to the need for a complete report or directory of museums in the United Kingdom, and rightly remarks that "the publication of such a report, and its annual revision, would tend to bring museums into close union and to a common knowledge of each other." It is pointed out that the preparation of an annual report of this character might be undertaken by a committee of the British Association ; and this suggests that it would be worth considering whether the Museums Association itself might not with advantage become part of the British Association, in much the same way as the Corresponding Societies are at present. The multiplication of annual meetings would thus be avoided, and excellent opportunity would be afforded for the discussion of the various aspects of museum work.

IN No. 4 of vol. i. of the "Geological Series" of the Field Columbian Museum Mr. Elmer S. Riggs treats of the Mylagaulidæ, an extinct family of rodents of which two new genera are described. It is remarked that the one prominent feature in these animals is the unusual development of the premolar to the exclusion of the posterior-lying teeth, evincing unusual capacity for crushing or grinding. A fossil egg from South Dakota is described in No. 5, by Dr. Oliver C. Farrington. The specimen is about 2 inches long by $1\frac{1}{2}$ inches. Covering most of the exterior is a thin black layer ·017 of an inch in thickness, and resembling an eggshell. The mass of the specimen is chalcedony, and this contains a white opalescent ovoid mass which appears to correspond with the yolk, and to yield evidence of organic matter. In shape this petrified egg resembles that of the Florida duck.

THE jumping-mice of the genus *Zapus* form the subject of part 15 of the "North American Fauna," edited by Dr. Merriam. It is noteworthy that whereas Dr. Coues in 1877 recognised but a single representative of this genus, ranging over a large area in North America, Mr. Preble, the author of the present memoir, considers himself justified in distinguishing no less than twenty North American species and sub-species, in addition to one Old World form recently described from Szechuan. The discovery of the Szechuan species adds one more link in the chain connecting the fauna of North-eastern Asia and North America; and when Manchuria and Mongolia are fully explored, representatives of the genus may be looked for in those countries.

ANOTHER important contribution to our knowledge of the North American mammal fauna is afforded by Dr. Allen's revision of the squirrels inhabiting the area north of Mexico, published in the August number of the *American Naturalist*. The last revision was in 1877, when six species and seven sub-species were recognised; Dr. Allen now admits ten species, with a large number of sub-species. With Mr. Nelson's revision of the species inhabiting Mexico and Central America, the group is now placed on a satisfactory footing, except as regards South America. Interesting results have been obtained by both writers as regards the effects of temperature and humidity on the coloration of members of the group. "In the drier interior mountains," for example, "certain sub-species of a group will be characterised by dull greyish upper-parts and white under-parts, while other sub-species of the same group inhabiting humid mountains near the coast will have nape and rump-patches sharply contrasting with the rest of the dorsal surface and bright ferruginous under-parts; increased humidity within the tropics being usually accompanied by increased intensity of coloration." This is zoology in its best sense.

A NOTEWORTHY addition to the fauna of the Australasian region is afforded by the discovery of a representative of the genus Balanoglossus in the New Zealand seas, since it has hitherto been unknown in the southern hemisphere, as, indeed, was the entire group of the Hemichordata till Mr. T. P. Hill found a species of Ptychodera in 1893. The new Balanoglossus is described by Mr. Benham in the September number of the *Quart. Journ. Microscopical Science*, and presents all the characteristic features of the genus. We may remind our non-zoological readers that Balanoglossus includes worm-like animals which approximate to vertebrates in the possession of a notochordal tract.—The same journal contains an interesting paper by Mr. E. S. Goodrich, of Oxford, on the existence of a communication between the blood-vascular system and the "cœlom" in the common leech.

YET another communication in the journal above quoted cannot be passed over without notice, although, from the extremely technical nature of the subject, such mention must necessarily be brief. The paper in question, which has been awarded the Rolleston Memorial Prize for 1898, is one by Mr. R. Evans, on the structure and metamorphosis of the larva of the common freshwater sponge. The work, which occupied a large portion of the author's time for a period of about eighteen months, was undertaken on the suggestion of Prof. Ray Lankester, and appears to have been admirably carried out. Several types of free-swimming larvæ have been detected, and their mutual relationship determined. From the occurrence of so-called "collar-cells" in sponges, and their early appearance in the free-swimming larvæ, coupled with their absence in all the Metazoa, the author is inclined to believe that the Porifera (sponges) have no relationship with the former group, but are more probably derived independently from primitive flagellate organisms.

IN their report for the year 1898 the Trustees of the Australian Museum, Sydney, deplore the insufficiency of the Government grant for purchase of specimens. It appears that in 1892, when the purchase grant was 1250*l*., the Colony was passing through a period of financial depression, in consequence of which the vote was reduced in the following year to 200*l*., this small amount having to suffice for the purchase of books as well as specimens. Although this amount has been slightly increased in the vote for 1898–99, the Trustees point out that it is altogether insufficient for the needs of the institution, so that many specimens are lost to the museum, while collecting has had to be suspended altogether. As the opportunity to acquire many of the ethnological specimens offered will never recur, it is to be hoped that Government, now that the finances of the Colony have taken such a decided turn for the better, may see their way to place the Trustees in a stronger position for carrying out the purposes for which the museum was founded.

MUCH more satisfactory reading than the foregoing is Dr. E. Thurston's report on the Madras Museum for 1898–99. As was fully stated in NATURE for May 26, 1898, the Director has been chiefly occupied in the investigation of the ethnology of the numerous native tribes of the Nilgiri and Anamalai Hills; the results of which are in course of publication in a series of valuable memoirs. Attention is directed in the report to the prospect of acquiring Mr. R. B. Foote's well-known collection of prehistoric Indian implements. It is also satisfactory to learn that the importance of fishery investigations is fully recognised by the Director.

MESSRS. HOLBORN AND DAY send us a reprint from *Wiedemann's Annalen* dealing with their investigations on the air-thermometer at high temperatures, a subject to which attention has been drawn by the recent discussions on platinum-thermometry at the British Association. The authors give comparisons of the results obtained by using containing vessels of platinum, iridium and porcelain respectively in these observations.

FROM Messrs. O. Lummer and E. Pringsheim we have received a copy of their paper on the partition of energy in the spectrum of a black body, published in the *Verhandlungen* of the German Physical Society (1). Experiments are described in which the radiations from an electrically heated cylinder were allowed to fall on a bolometer, and the energy tabulated for different temperatures and wave-lengths, the results being compared with those given by Paschen's formula.

IN the course of a paper on Euclidian geometry, contributed to the *Bulletin de la Classe des Sciences* (Brussels), M. Charles Lagrange remarks that the condition necessary for introducing doubts in geometry, a condition without which no argument exists against the certainty of Euclidian space, would consist in presenting two different admissible definitions of space. Up till now only one definition has been given; and this assumes the existence of Euclidian space. The author considers that the new geometry has in fact established the contrary of what it claimed; it has attempted to throw doubts on the physical reality of the Euclidian postulate, and it has only succeeded in confirming it.

ENGLER AND PRANTL's great work, *Die natürlichen Pflanzenfamilien* is now completed, as far as flowering plants are concerned, by the publication of Nos. 184 5, completing Parts ii.–v.

PROF. D. G. FAIRCHILD, of the U.S. Department of Agriculture, gives, in the *Botanical Gazette* for August, an interesting sketch of the general features of the flora of Venezuela, derived from his experience as botanist to the expedition fitted out by

Mr. Barbour Lathrop, of Chicago, for the exploration of that country.

IN honour of the 150th anniversary of the birth of Goethe (August 28, 1899), Dr. H. Potonié reprints, from his *Naturwissenschaftliche Wochenschrift*, a treatise on the morphological origin of the leaves of plants. The importance is shown of the part played by Goethe's theory of metamorphosis in the elucidation of problems connected with vegetable morphology, and it is pointed out that the introduction of the term "morphology" itself is due to Goethe.

VOLUME XV., part 7 of the *Nouveaux mémoires de la Soc. Imp. des Naturalistes de Moscou* is chiefly occupied by a monograph of the genus Sphæronema (Ascomycetes) by M. A. Jaczewski. He enumerates and describes seventy-two good specimens of the genus, seventy-seven being rejected as not properly belonging to it, besides eight others, for which a new genus, Pseudographium, is formed. D. Strémonkhoff has also a short paper on the ammonites *Phylloceras zignodianum* and *Lytoceras adelae*, from the schists of Balaclava.

PROF. VERNON L. KELLOGG gives an interesting account, in the *American Naturalist* for August, of the Hopkins Sea-side Laboratory on the Bay of Monterey, connected with the Leland Stanford Junior University. Monterey Bay and the Bay of Naples are stated to be much alike in the abundance and representation of species. The Bay is a middle point between the north and south zones of the Pacific coast. The regular sessions of the laboratory are held in June and July of each year; but investigators and students working without instruction may continue their work though the summer. Courses of lectures are given in general zoology, embryology and cryptogamic botany.

PRACTICAL directions for stuffing and setting up birds are given in "Bird Stuffing and Mounting," the fifth edition of which has been published by Messrs. J. and W. Davis, Dartford. To students of natural history and collectors this practical manual of taxidermy should be of service.

IN connection with the Parents' National Education Union, a course of lectures to young people will be delivered by Mr. Cecil Carus-Wilson at the Horbury Rooms, Notting Hill Gate, during this month and next. The titles of the lectures are "The Wonders of Rain," "Ice and Glaciers," "The Mighty Ocean," "Volcanoes and Geysers." The aim will be to interest and entertain children by directing their attention to the natural phenomena which surround them, and upon which the studies of geography, geology and physiography are based.

THE additions to the Zoological Society's Gardens during the past week include a Macaque Monkey (*Macacus cynomolgus*, ♂) from India, presented by Dr. Montgomery Smith; an African Civet Cat (*Viverra civetta*) from West Africa, presented by Mr. W. H. Hardwick, R.N.; a Two-spotted Paradoxure (*Nandinia binotata*) from West Africa, presented by Mr. F. Gordon; a Black-backed Kaleege (*Euplocamus melanonotus*, ♀), two Sonnerat's Jungle Fowls (*Gallus sonnerati*, ♀ ♀), a Wood Francolin (*Francolinus gularis*) from India, presented by Mr. W. F. Pedler; four Green Lizards (*Lacerta viridis*), European, presented by Mr. F. K. Preston; two Black-eared Marmosets (*Hapale penicillata*) from South-east Brazil, a Hocheur Monkey (*Cercopithecus nictitans*), a Ruppell's Parrot (*Paeocephalus rueppelli*) from West Africa, a Maroon Oriole (*Oriolus trailii*) from India, two Radiated Tortoises (*Testudo radiata*) from Madagascar, deposited.

## OUR ASTRONOMICAL COLUMN.

NEW ALGOL VARIABLE IN CYGNUS.—The following *minima* occur at convenient times for observation during October:—

$$\text{D.M.} + 45^\circ\cdot 3062. \begin{cases}\text{R.A. 20h. } 2\cdot 4\text{m.}\\ \text{Decl.} + 45^\circ\ 53'\end{cases} (1855)$$

| | | d. | h. | m. | | | d. | h. | m. |
|---|---|---|---|---|---|---|---|---|---|
| 1899. | Oct. | 5 | 8 | 43 | 1899. | Oct. | 23 | 15 | 43 |
| ,, | ,, | 14 | 12 | 13 | ,, | ,, | 28 | 5 | 28 |

STELLAR PARALLAX.—M. Osten Bergstrand, of the Upsala Observatory, has recently been engaged in measuring photographic chart plates to determine any possible evidence of stellar parallax (*Astr. Nach.*, Bd. 150, No. 3593). The photographs were taken with the photographic refractor of 33 cm. aperture and 4·33 metres focal length during 1897 and 1898, all the measures being made with a Repsold micrometer in conjunction with a "reseau" by Gautier. After describing the method of measurement adopted, the following values for parallax are given:—

| Star. | Parallax. | |
|---|---|---|
| Σ 1516 A. | $+0''\cdot 080 \pm 0''\cdot 011$. | From measures of *four* comparison stars on *fourteen* plates. |
| A Oe. 11677 | $+0''\cdot 192 \pm 0''\cdot 013$. | From measures of *eight* comparison stars on *nine* plates. |

The latter star is remarkable as having a very large proper motion—about 3″ annually.

PRECESSION TABLES.—We have received a volume compiled by Dr. Downing, superintendent of the English Nautical Almanac, containing a series of tables which have been constructed so as to give the values of the precessions corresponding to Newcomb's value of the Precessional Constant, as deduced by him in accordance with the request made to him at the International Conference on Fundamental Stars, held in Paris in May 1896. Prof. Newcomb's original results are published in the Astronomical Papers of the American Ephemeris, vol. viii. part i. The present tables are constructed for Epoch 1910·0, but the method of setting out is such that they can be used with facility for at least ten years before and after that date.

LONGITUDE FROM MOON CULMINATIONS.—In a communication to the Royal Astronomical Society (*Monthly Notices*, R.A.S., vol. lix. p. 513, May 1899), Mr. D. A. Pio, of Syra, Greece, brings forward a new method of determining local longitude. The determination of culmination is only undertaken to give the precise instant of the moon's transit across the local meridian, thereby obviating the necessity of an accurately adjusted transit instrument with the many precautions connected with it. The instruments required are a sextant, artificial horizon, and a well-rated chronometer, together with the usual tables. Instead of finding the right ascension of the moon directly as usual, the author obtains it indirectly by finding the mean local time of meridian passage, converting to sidereal time, and then adding the right ascension of the mean sun at local transit. The difficulty of finding the mean local time of transit is got over by observations of equal altitudes, the resulting *time of culmination* requiring to be corrected to reduce it to *time of transit*. Local mean time is determined by similar measures of equal altitudes of the sun. The difference between the times of transit of sun and moon thus obtained is, of course, the mean local time of the moon's transit. The remaining calculations are precisely similar to the usual method of lunar distances, so that the novelty of the new method consists in the substitution of the use of "equal altitudes" with a sextant for meridian passage with a transit circle; in fact the observation is really a chronometric one. The difference in time between the transits of sun and moon should be correct to the *tenth* of a second, and to facilitate this the two observations should be chosen as near together as possible. The method is stated to be unsuitable for high latitudes. The necessary formulæ for "reduction to meridian" are included in the article, and an example fully worked out to illustrate the exact method of procedure.

## THE ROYAL PHOTOGRAPHIC SOCIETY'S EXHIBITION.

THE forty-fourth annual exhibition of the Royal Photographic Society was opened to the public last Monday at the Gallery of the Royal Society of Painters in Water Colours, 5A Pall Mall East. As is usual, by far the greater number of the exhibits claim attention on account of their pictorial interest; but the technical and scientific section is considerably larger than it has been at the recent exhibitions. No doubt next year there will be a still further increase in the importance of this section, as the Society will then have at their disposal the larger accommodation available at the New Gallery in Regent Street.

The judges in this Section, Captain Abney, Mr. T. Bolas and Mr. Chapman Jones, have selected three of the exhibits as showing progress of sufficient importance to merit the special distinction of receiving the Society's medal Taking these as they stand in the catalogue, the first is awarded for copies of an etching, a mezzotint, a silver print, an engraving, a lithograph, a pen and ink drawing and a pencil drawing, by Mr. J. Hort Player, by what he calls the "absorption" process. The method is to place the picture or document that is to be copied face uppermost, to lay upon it a piece of "bromide paper" with its sensitive surface in close contact with the picture, and then to expose with the bromide paper towards the light, so that the light passes through the sensitive surface before it comes in contact with the picture being copied. On development this furnishes a negative from which prints are obtained as usual. The great advantage of the process is that the picture or document need not be transparent, or if it is on ordinary paper there may be other writing or drawing on the reverse side. Those who examine these specimens of Mr. Player's will be surprised at the wonderful perfection to which he has brought the process, and its universal applicability is proved by the great variety in the character of the originals that he has worked from.

Another medal is awarded for a cross-lined screen for use in the making of half-tone photo-typographic blocks, by Messrs. J. E. Johnson and Co. It has two hundred lines to the inch over its whole area of thirteen by sixteen inches, the especial feature of the screen being the great regularity of the ruling and the freedom from blemishes in so large a plate. Two still larger ruled screens are also shown by the same firm, of 133 and 150 lines to the inch respectively.

Mr. E. Sanger Shepherd receives a medal for his "trichromatic light filters." The three-colour printing methods that have been brought to such perfection depend upon the fact that the phenomena of colour vision can be explained on the assumption of three colour sensations. By photographing separately the light that affects each of these, and superposing the prints from the negatives, each being printed in its corresponding colour, the same sensation of colour will be produced by the resulting composite print as by the original. In order to photograph separately the colours that correspond to each sensation it is necessary to stop the light that is not wanted by means of a suitably coloured screen, which is generally placed against the lens. But these colour screens have also to compensate for the differences between the sensitiveness of the plate used for the different colours and their visual intensity. Heretofore we believe the colour screens have been prepared by the method of trial and error, and though astonishingly good results have sometimes been produced, we may well expect greater certainty and more definite success by the use of screens that have been adjusted by definite methods of measurement as these of Mr. Sanger Shepherd's have been. The screens are adjusted to the Cadett "rapid spectrum plate" and tested by the colour sensitometer recently devised by Captain Abney. The exact tints are obtained by the superposition in each case of films variously dyed.

Among the cameras shown, the "Gambier-Bolton" hand camera by Messrs. Watson and Sons is worthy of especial attention, as embodying the requirements found by Mr. Bolton in his large experience in photographing animals. The camera is for 5 × 4 inch plates, and is by no means a compact apparatus suitable for carrying about for obtaining snap-shots. It is designed for lenses of much greater focal length than usual that the image may be large, and as the lenses must be rapid, they must be large and consequently heavy. The camera has many conveniences adapting it to the special work it is constructed for. The same exhibitors show the "Kromaz" colour apparatus. This is somewhat analogous to Ives' well-known "Kromscop," its only merit presumably being that it is cheaper. Instead of taking a complete stereoscopic negative for each of the three colours, only two pairs of negatives are taken—one through a green screen, and one of the other pair through a red and the other through a blue screen. The view shown is crude, and hardly comparable with the exquisite results obtained with Ives' "Kromscop."

The Lippmann interference colour process is exemplified by three photographs by Mr. Edgar Senior—two views and a spectrum of the arc light. These would show to better advantage if the correct position of the eye were indicated in each case. The views are very good specimens of the results obtainable by this method, but the spectrum is especially worthy of commendation. In addition to these there will be found upon the tables many little conveniences, some of a distinctly novel kind, that will prove of service to those who photograph either for scientific purposes or for mere pleasure. A small printing frame, with six slides so that the sensitive surface may be exposed in six separate strips, is exhibited by Messrs. Marion and Co., and is applicable to a great variety of experimental purposes; and a frame, by Mr. T. Webster, that opens like a book, the negative being entirely removed from the print, so that the whole of the print may be examined at any time, though perhaps not very novel in principle, is likely to prove useful.

But the most remarkable of all the exhibits is not mentioned in the catalogue, although examples will be found on the tables. These are some plates prepared by General Waterhouse, the honorary secretary of the Society, to illustrate the fact that a polished surface of metallic silver is sensitive to light, and that the resulting latent image may be developed by mercury vapour, after the manner of daguerreotype plates, or by the methods of so-called physical development, after the manner of wet collodion plates. The exposures necessary are long, generally two to three hours, to direct sunshine in August. To exclude any effect of the stencil plate used as the negative to print from, a sheet of mica was placed between it and the silver surface, and the silver surfaces experimented with have been electroplated copper plates prepared for daguerreotype work, silver foil and commercial silvered glass, the surface in each case being polished with plate powder. The surfaces of other metals have given similar results. Many years ago Moser made similar experiments, developing the images with the vapour of water and of mercury, but (speaking without reference) we think that he did not go so far as to develop the images by the deposition upon them of silver from a solution. General Waterhouse seems to have brought these experiments and practical photography a little nearer together, and we shall receive with great interest any further results of his investigations. C. J.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

DR. A. WILLEY, formerly Balfour Student of the University of Cambridge, has been appointed Lecturer on Biology in Guy's Hospital.

THE inaugural address of the coming session of the City and Guilds Central Technical College will be given at the College, in Exhibition Road, on Tuesday afternoon next, at three o'clock, by Sir Andrew Noble.

*Science* makes the following announcement:—The plans for building the University of California, submitted by M. Bernard, of Paris, have received the first prize in the competition arranged by Mrs. Phœbe Hearst. The cost of the buildings is estimated at over 15,000,000 dollars.

IN addition to 300,000 dollars subscribed from various sources for an endowment of Brown University, made on condition that 2,000,000 dollars be collected, Mr. John D. Rockefeller has offered to give 250,000 dollars on condition that 1,000,000 dollars be obtained before the commencement of next year.

A PROSPECTUS just received shows that the work of the South African School of Mines, Kimberley, is now carried on in suitable premises, which were completed in the beginning of this year at a cost of about 9000*l*. Of this sum, 2000*l*. was given by the Government of Cape Colony, 2000*l*. by the De Beers Company, and 5000*l*. was borrowed. The school has been established to carry out part of a scheme for the training of

mining engineers in South Africa. The courses of instruction are intended to prepare students for a diploma of mining engineer, or for the degrees of B.Sc. or M.Sc. in mining engineering. Theoretical and practical instruction is given, under the direction of the principal, Mr. James G. Lawn, in mining, mechanical and electrical engineering, metallurgy, assaying, surveying and other subjects. Practical work is carried on in the mines and workshops of the De Beers Company, and also in various mines at Johannesburg. The time spent at Johannesburg is devoted to a special study of the cyanide process in all its developments, of the electrical machines and appliances at the mine where the student is working, of the methods of assaying and surveying and of the economics of mining on the Rand. A thorough training for mining engineers is thus provided in connection with the school, the course of work described in the prospectus being of a very satisfactory character.

THE London Technical Education Board have arranged several advanced evening science courses in connection with King's and University Colleges, to commence next month. The courses of instruction will afford an opportunity to students who can study only in the evenings to obtain instruction in well-equipped University laboratories, and will make available to evening students the same advantages as are enjoyed by University day students, but they are only intended for those who are practically engaged during the day in some trade, business or occupation.—A course of twenty lectures on civil engineering will be given by Prof. Robinson, at King's College, on Mondays, from 7 to 9, commencing on Monday, October 9. Part of the time will be spent in working out engineering calculations by graphical methods.—A course of about twenty demonstrations will be given by Prof. Capper and Mr. H. M. Waynford, at King's College, on Thursday evenings, 7 to 9, upon "Steam and Gas Engines and General Laboratory Work," commencing October 12. The latter portion of each evening will be devoted to experimental and practical work in the engineering laboratory in illustration of the lectures.—A course of about twenty lectures on mechanical engineering will be given by Prof. Hudson Beare, at University College, on Friday evenings from 7.30–9.30, commencing Friday, October 13.—A special course of lectures on alternating currents will be given by Prof. Wilson, at King's College, on Monday evenings, at 6.30 p.m., beginning October 9.—The following courses have been arranged to be held under the direction of Prof. Ramsay, at University College. In both of these courses the work will be *original*. (*a*) A course of twelve lectures on sewage and its purification, by Dr. Samuel Rideal, on Mondays, at 5.30 p.m., commencing November 6. (*b*) A course of lectures on spectroscopy and spectrography will be delivered by Mr. E. C. C. Baly.

## SCIENTIFIC SERIAL.

*Wiedemann's Annalen der Physik und Chemie*, No. 8.—Limits of the solid state, by G. Tammann. Experiments on a number of organic bodies show that even when the heat of fusion is very nearly or accurately zero, the difference between the specific volumes of the liquid and the crystals is considerable.—Magnetic properties of hematite, by A. Abt. The maximum magnetic moments of three equal prisms, of pyrrhotite, hematite and magnetite respectively, were found to be in the ratio of 1 to 2·356 to 3·237. Pyrrhotite shows the smallest magnetisation in comparison with its percentage of metallic iron.—The blue steam-jet, by A. Bock. A sky-blue colour is imparted to a steam-jet by sending through it a current of air saturated with hydrochloric acid. The jet, as regards colour, polarisation and diffraction, shows a close analogy with the atmosphere.—Resistance of alloys, by R. H. Weber. To measure the resistance of brittle alloys, like those of zinc and copper in which the zinc preponderates, the author employs the alloy in the form of thick plates or cylinders. A magnetic needle is made to vibrate over the plate, and its logarithmic decrement is directly proportional to the conductivity of the alloy. The method has the further advantage that the substance need not be exposed to much mechanical working, such as is involved in wire-drawing. Work consumed in a spark gap, by E. Riecke. In a 40-plate Toepler machine, the work consumed with a gap of 2 cm. is 1·64 watts per turn, and with a gap of 6 cm. it is 5·27 watts. A further increase of the width of gap diminishes the work of the spark.—Pressure in the spark, by E. Haschek and H. Mache. By noting the increase of pressure in a vacuum tube on sparking, and the volume of the spark itself, the authors arrive at an estimate of the pressure within the spark. It is of the order of fifty atmospheres.—Potential gradient at the anode, by C. A. Skinner. The drop of potential from the anode to the adjoining gas during a low discharge is about 20 volts. This increase is to about 40 volts within a distance of a few millimetres from the anode; but there is no potential gradient within the thin luminous layer immediately adjoining the anode. The greater the drop of potential at the anode, the less is the potential gradient in the anode light.—A radio-active substance, by E. de Haën. By extraction from a large quantity of uranium ore, the author has obtained substances which possess the properties ascribed to "radium" in an extraordinary degree. One preparation exhibits all the properties of Becquerel radiation, and, in addition, possesses the property of being strongly luminous. This luminosity is rapidly impaired by moisture, and can only be restored by melting the substance in the oxyhydrogen blowpipe.

## SOCIETIES AND ACADEMIES.

### PARIS.

**Academy of Sciences**, September 18.—M. Maurice Lévy in the chair.—Variations of volume in Portland cement resulting from setting and hygrometric state, by M. Considère. The expansions of cement prisms immersed in water were studied for a period of over two months, comparisons being made between loaded and unloaded prisms. The expansions increased very regularly, and were much less with a mixture of cement and sand than with pure cement. Owing to this gradual expansion, metal plates holding cement under water may be submitted to much greater stresses than has been hitherto supposed.—On the development of a holomorphic function at the interior of a contour in a series of polynomials, by M. Renaux.—On some experiments designed to confirm Ampère's hypothesis relating to the direction of the elementary electromagnetic action, by M. W. de Nikolaiève.—On Egyptian pottery, by M. H. Le Chatelier. Analyses of five different specimens of Egyptian pottery are given, together with a reproduction of the microscopic appearance of two of them.

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THURSDAY, OCTOBER 5, 1899.

## BERTHELOT'S AGRICULTURAL CHEMISTRY.

*Chimie végétale et agricole.* Par M. Berthelot. Four volumes. Pp. xvi + 511, vi + 441, vi + 517, vi + 528. (Paris: Masson, 1899.)

THE ancient Château de Meudon, Seine-et-Oise, which was left in ruins at the end of the war of 1870, was thirteen years later converted into an agricultural experiment station by the French Government, and permanently attached to the Professorship of Organic Chemistry in the Collège de France. In the four bulky volumes now before us, the professor, M. Berthelot, has brought together an account of the various investigations carried out at the station between 1883 and 1899, under his direction, with the assistance in many cases of M. G. André. Besides these reports, the volumes contain an account of several earlier investigations by M. Berthelot. We have in fact brought before us the whole of his investigations on plants, soils and various cognate matters, carried out during the last forty years.

Agricultural chemists will heartily welcome the publication in such a convenient form of this great mass of original investigation. M. Berthelot is well known as a first-class man of science, and as one of the most prolific and versatile workers of the present age. The new ideas he has brought forward concerning many obscure points in agricultural chemistry will be highly valued. Nevertheless, those acquainted with the peculiarities of M. Berthelot's work will not be surprised that a cautious critic is unable always to accept the conclusions to which he has apparently too easily arrived. The more startling and novel are the conclusions brought before us, the more thorough and unmistakable ought surely to be the basis of fact on which these conclusions are built. A few experiments, relating to only a part of the facts in question, must fail to carry conviction when new laws are propounded, or we are asked to surrender as a mistake views previously arrived at after much patient research.

It will be gathered from what has just been said that the papers in the volumes before us are of unequal value. All the investigations are indeed highly suggestive, and no experimental investigator would desire one of them to be omitted; but students of agricultural chemistry will not unfrequently find it advisable to examine with much care the evidence brought forward before accepting all the conclusions of the author.

That we may do no injustice to the book we will, in the first place, call attention to the very valuable investigation upon the nature and properties of humus, which occupies more than one hundred pages in the fourth volume. The elucidation of the chemical nature of humus has been regarded as an almost hopeless problem by the ordinary agricultural chemist. Berthelot has brought to bear upon the subject the methods and conceptions of modern organic chemistry, and his work has resulted in a considerable increase to our knowledge.

Berthelot has carefully studied the composition and properties of the simple nitrogen-free humus obtained by boiling sugar with hydrochloric acid. It appears to be a mixture of a condensed anhydride and hydrate, the simplest expression for the former being $C_{18}H_{14}O_6$. It swells up in water, forming a colloid body. It absorbs a considerable quantity of alkali from an aqueous solution. One third of the potash or soda thus absorbed is permanently retained in a practically insoluble condition after long washing with water. Placed in contact with ammonia an insoluble amido-compound is produced, from which ammonia is not recovered by boiling with magnesia. The oxidation of humus under the influence of light, and its more rapid oxidation in the presence of alkali are also studied. The heat relations of the principal reactions have also been ascertained. All this is fundamental work of very great importance, and throws much light upon the behaviour and functions of humus in a soil.

The natural humus in soil is also studied, and the action of acids and alkalis upon it investigated. The gradual formation of ammonia when the nitrogenous humus of soils is boiled with weak acids, soluble nitrogenous compounds being simultaneously produced, is pointed out as in full agreement with the assumed amido nature of the humic matter. The humus of soils is, however, a very complex substance; it may contain a very distinct amount of sulphur, and even phosphorus, in a state of organic combination. It will certainly be a novel fact for most agricultural chemists to hear that a soil may yield 0·183 per cent. of phosphoric acid when boiled with strong hydrochloric acid, 0·222 per cent. when the silica has been entirely removed by hydrofluoric acid and 0·292 per cent. when the soil is burnt in oxygen gas and the products retained by sodium carbonate. The excess obtained by combustion in oxygen is regarded by Berthelot as representing the phosphorus in organic combination. This part of the subject clearly requires much further investigation. Phosphorus, if present, is possibly a survival of the nuclein occurring both in the animal and vegetable kingdom.

We take our next example from one of the less satisfactory of M. Berthelot's investigations, in which the evidence brought forward seems quite insufficient to warrant the conclusions which he seeks to establish.

He has determined the quantity of nitrates present in certain plants, and has conceived the idea that plants have the power of producing nitrates abundantly in their own tissues. This assumption, if proved, would clearly furnish an entirely new departure in vegetable physiology One would have thought that to establish such an hypothesis the plant would have been grown in a medium supplying no nitrates; any appearing in the plant would then clearly be due to the work of the plant itself. M. Berthelot makes no such experiment. To establish his position, he grows the plant (borage or *Amaranthus*) in the open field, without any knowledge of the quantity of nitrates produced in the soil during the season of growth, and without taking into account the upward movement of subsoil water containing nitrates during the dry summer of his experiment. He is satisfied by ascertaining that on September 25 a square foot of soil contained only about 1/20 of the quantity of nitrate contained in the plant pulled up from it, and that a similar bulk of soil taken at the beginning of the season, from another part of the



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field, contained a similar quantity of nitrate to that found in the exhausted soil around the plant at the end of the season. The next year he finds that the soil of the field, when deprived of vegetation, doubled its contents in nitrates between June 4 and "the end of the season"; but this rate of increase was insufficient to account for the nitrates found in the crop the *previous year!* Finally, to prove that the plant contains a nitrifying agent, a single experiment is made by introducing a fragment of the stem of *Amaranthus* into a flask containing 300 grams of sterilised and exhausted soil. At the end of eleven weeks six milligrams of saltpetre were found in the soil. A blank experiment, made with soil only, was for some reason only continued for six weeks.

Data such as these are quite insufficient to convince a critical reader. Our confidence in the investigation is not increased by reading that the growth of a *single* crop in the field diminished the nitrogen in the soil from ·275 to ·173 per cent., and the potash of the soil in the neighbourhood of the roots from ·64 to ·47 per cent. Nor by remarking that the same figures for nitrates in the soil are first quoted as kilograms, and are afterwards always spoken of as grams.

The whole of the first volume is occupied with an account of investigations on the fixation of atmospheric nitrogen by soil and plants. M. Berthelot has been a pioneer in this branch of inquiry. The peculiar function of the organism forming the nodules on the roots of leguminous plants is now universally recognised. A similar case of symbiosis between a nitrogen-assimilating organism and certain algæ is also well known. Not so well known is the isolation of a bacillus from the soil by Winogradsky, which when supplied with sugar, and protected from the action of oxygen, is capable of assimilating atmospheric nitrogen. This organism succeeds in assimilating nitrogen from ordinary air when it is associated with ærobic organisms which appropriate the oxygen, and thus produce conditions suitable for the growth of the bacillus assimilating nitrogen.

Both in the case of the reaction in the leguminous rootlets and algæ, and in the case of the reaction *in vitro*, studied by Winogradsky, we have a clear indication of the source of the chemical energy which accomplishes the difficult task of bringing nitrogen into a state of organic combination; in every case we have carbohydrates abundantly present, and in Winogradsky's experiments we have a demonstration that the quantity of sugar fermented is a measure of the quantity of gaseous nitrogen assimilated.

With this principle before us we should suppose that a soil entirely destitute of vegetation could fix nitrogen only at the expense of its own organic matter; carbon would, in fact, be lost in the operation of fixing nitrogen. If, on the other hand, certain green algæ or leguminous plants were present, fixation of nitrogen might be accompanied by an actual gain of organic matter.

According to Berthelot's experiments, soils destitute of visible vegetation may gain large quantities of nitrogen when exposed to air. Even subsoils of argillaceous sand or clay, containing mere traces of carbon or nitrogen, are capable of gaining considerably in nitrogen when exposed to air. From an agricultural point of view, the quantities of nitrogen fixed are very considerable. Layers, 7 inches deep, of three surface soils from Meudon, fixed in 11 weeks from 70 lbs. to 130 lbs. of nitrogen per acre, quantities equivalent to 6–11 tons of farmyard manure. If this enrichment of soil by mere exposure to air is a fact, we shall be very anxious to know what are the precise conditions and limitations of such a beneficial action. Scientific agriculturists will be loath to admit that the exposure of a soil uncovered by vegetation tends to its permanent enrichment; the process of weathering tends, on the contrary, to the exhaustion of soil capital, and not to an increase of nitrogenous organic matter.

Berthelot's trials of various organisms yielded results of a similar favourable character. Out of seven organisms tried five produced an active fixation of nitrogen. The composition of the medium was apparently indifferent, for a mixture of certain bacilli from soil with kaolin determined an increase of 32 per cent. of the original nitrogen in one case, and an increase of 150 per cent. in another. Among the organisms fixing nitrogen, Berthelot includes the common mould *Aspergillus niger*.

In the last section of this volume Berthelot describes experiments which lead him to the conclusion that the natural electrical conditions, both of soil and plant, aid in bringing about the fixation of nitrogen from the air.

It is to be regretted that the large amount of work contained in these volumes is not of a more thorough and definite character, but we are very thankful that the investigations have been published. R. W.

## OUR BOOK SHELF.

*Bird Life in an Arctic Spring; the Diaries of Dan Meinertzhagen and R. P. Hornby.* Edited by Mrs. G. Meinertzhagen. Pp. iii + 150. Illustrated. (London: Porter, 1899.)

A PATHETIC interest attaches to this volume, as being practically a memorial to a most promising and talented young ornithologist, whose life was unhappily cut short almost at the outset of his career. The late Mr. D. Meinertzhagen was essentially a lover of bird-life, and thus a naturalist in the very best sense of that somewhat abused word. But he was much more than this, being an artist of great talent, whose sketches and etchings of birds form some of the most beautiful delineations of feathered life it has been our fortune to see. In addition to those illustrating the text itself, nearly thirty of these talented sketches have been photographically reproduced as an appendix to the present volume, and serve not only to enhance the general interest of the latter, but likewise to convey an excellent idea of the artistic capacity of the author of the journal which constitutes its main claim to attention.

As we gather from the preface, the book is mainly intended for private circulation, and only a limited number of copies are offered to the general public. On the whole, the editor has exercised a wise discretion in endeavouring to preserve the journal of her son as much as possible in its original form, although it must be confessed that a little fuller supervision on the part of a trained ornithologist than has been permitted would have been advantageous in a few instances.

The journal is divided into two portions, the first and longer by Mr. Meinertzhagen, and the second by his companion Mr. Hornby. The trip to Lapland, of which these form the chronicle, was undertaken in 1897; and the journal of the originator breathes out the enthusiasm of an ardent bird-lover. The two companions appear to have visited spots to which few if any Englishmen

have penetrated since Wolley's time; and in collecting eggs they suffered almost from *embarass des richesses* on account of the numbers that were brought in by the natives. One of the objects of their desire was to obtain a clutch of Smew's eggs, but it was not an easy matter to identify these without some of the down from the nest. At length they succeeded in obtaining what they thought were the right eggs; and their acumen was confirmed on arrival in England by the identification of the specimens from the down.

A section of the volume is also devoted to an account of the magnificent collection of raptorial birds maintained by the late author of the first journal at his father's seat, Mottisfont Abbey, Romsey. This collection, which is stated to be one of the finest in England, is still maintained; and the account shows how it is possible to keep such splendid birds in perfect condition. Altogether, the bird-lover will find much to interest him in this charming little volume. R. L.

*Progressive Lessons in Science.* By A. Abbott, M.A., and Arthur Key, M.A. Pp. xix + 320. (London: Blackie and Son, Ltd., 1899.)

THIS book consists of two parts—the first, by Mr. Abbott, dealing with the non-metallic elements found in animal and vegetable substances; the second, by Mr. Key, on the detection and distribution of the elements in animal, vegetable and mineral substances. The former part contains a course of experimental work in chemistry of a kind with which many text-books have made us familiar. All that need be said of it is that most of the experiments are suitable for performance in the laboratory by beginners in chemistry, and that the book will assist the progress of rational methods of science teaching. With regard to the second part, though the plan has something to commend it, the execution is open to criticism. Mr. T. G. Rooper, who generously endeavours to assist the volume by his introduction, remarks upon the idea to which we refer. "The most original feature in the book is the set of experiments which illustrate the composition of food-stuffs. Starting with a table of the chief constituents of the blood, the author proves the presence of each by the use of an ingeniously-devised test. He then traces each constituent through animal life to the vegetable life on which animal life is supported, and thence to the soil from which the plant derives it, and finally to the rock, by the disintegration of which the soil is formed." There are several grave objections to this method of procedure as it is here presented. Students are *told* the tests which have to be applied to detect different substances, hence the experiments are not in advance of the test-tube practice which is fast giving place to more intelligent practical instruction. Moreover, the object of the experiments is too complicated to be of real educational value to beginners; and, finally, very few students have the time to do so much experimental work. Originality in text-books is a very commendable characteristic, but the authors should know that practicability is an even more important factor to consider. In its present form the book may be of service to a few teachers of domestic science and hygiene, but we do not think any other useful purpose will be served by its publication.

*De la Méthode dans la Psychologie des Sentiments.* By F. Rauh. Pp. 305. (Paris: Félix Alcan, 1899.)

THIS is a valuable monograph the merit of which is unfortunately partly concealed by a singularly obscure and unattractive literary style. M. Rauh's principal object is to enter a warning against the growing tendency of psychologists to neglect the adequate description of complicated facts, and to corrupt their science in its infancy by excessive reliance upon over-simple metaphysical and psychophysical theories. Psychology, as he well points out, possesses as yet no such simple and universal generalisation as that of the conservation of energy; in the present state of the science any single theoretica generalisation is premature; for the full description of the facts of mental life we need many points of view, each represented by a different tentative hypothesis. Thus the emotions, which form the immediate subject of the essay, may be studied as concomitants of physiological changes in the organism, as embodying a *quasi*-judgment on the part of the organism as to what is beneficial or harmful, as manifestations of the "will to live," or finally as special phenomena calling for independent description and classification. Each of these points of view throws light upon some characteristic of human emotions, and none of them can be neglected in a complete psychology of sentiment. In the course of the argument many one-sided theories, especially that of Prof. James as to the organic concomitants of emotion, receive really trenchant criticism. Like most French writers, M. Rauh is particularly happy in what may be called "psychological diagnosis"; his too rare descriptions of the various emotional "temperaments" are subtle and illuminating. On the other hand, he makes occasional slips which partly vitiate his reasoning. In his deductions from the supposed existence of special "pain-conducting" nerves, for instance, he forgets to allow for the possibility that what the nerve conducts is the special presentative element, the "racking," "stabbing," or "burning" sensation rather than the painfulness of it. Again, he scarcely lays enough stress on the fact that our emotional state at any moment depends, not on isolated sensations, but upon the total complex of our sensations at the moment. And, finally, to the present writer at least, the conception of "psychical forces," of which M. Rauh makes great use, is exceedingly obscure. It is a pity that terminology, which has led to so many confusions, even in dynamics, should be needlessly transported into psychology. A. E. T.

*Histoire Abrégée de l'Astronomie.* Par Ernest Lebon. Pp. vii + 288. (Paris: Gauthier-Villars, 1899.)

THIS book, as its title implies, is not intended as a complete history of the progress of astronomical science from the earliest day, but is devoted to rendering a brief account of the main steps in this progress, and at the same time giving us short biographical sketches of the chief workers in this branch of science. The subject is divided into three parts. The first deals with the ancient period which ends in the middle of the sixteenth century: only eighteen pages are devoted to this portion, so that the reader can rightly conclude that only a very general sketch has been attempted. The second or modern period, extending to the middle of the nineteenth century, commences with the system of Copernicus, and ends with an account of the state of the science at the time of the death of the illustrious astronomer of the Königsberg Observatory, Friedrich-Wilhelm Bessel. The last, or contemporary, period is contained in 125 pages. M. Lebon divides this portion of the book into ten chapters, dealing in each with the progress made in separate branches of the subject. Thus we find first an account of the advance made in celestial mechanics, then the progress in observational astronomy, spectroscopy, geodesy, photography, &c. Each of these reviews is brought well up to date, and contains a good general survey of the progress made. A useful addition to the book will be found in the biographical and bibliographical dictionary which follows this last portion. Besides a small chart of the northern hemisphere, which apparently has little utility in such a book as this, the illustrations include a set of sixteen processed reproductions of portraits of celebrated astronomers. Not only should astronomical readers find this book a welcome addition to their libraries, but those interested in the welfare of this, the oldest, of sciences, will peruse these pages with advantage.

## LETTERS TO THE EDITOR.

*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### The Intake of Carbon Dioxide—a Correction.

WILL you give me the opportunity of making the following correction in my Presidential Address to the Chemical Section of the British Association.

I stated incidentally that Mr. F. F. Blackman, in his well-known experiments on the intake of carbon dioxide into the two sides of an assimilating leaf, employed air enriched with that gas to the extent of 4 per cent. and upwards.

Mr. Blackman has pointed out to me that in the experiments in question he used air containing only from 1·8 to ·33 per cent., and that since the publication of his earlier results he has still further reduced this amount. In fact he is of the opinion that his method is applicable to the measurement of the intake of carbon dioxide of even a much greater degree of dilation.

The error was an inexcusable one on my part, but does not affect the main argument that the natural rate of intake cannot be directly deduced from experiments in which the carbon dioxide content of the air materially departs from the normal amount 0·03 per cent. HORACE T. BROWN.

52 Nevern Square, Kensington, S.W., September.

### Geological Time.

IN his Presidential Address to Section C at Dover, Sir A. Geikie has offered a bold challenge to Lord Kelvin and those who agree with him by calling upon them to give due weight to geological phenomena in forming an estimate of geological time. Permit me to say what I think about it.

It seems to me probable that, when the grand idea of the universal dissipation of energy had occurred to Lord Kelvin, he saw that the principle must be applicable to the earth, and that, if the law of conduction of heat could be used, he might from it obtain an estimate of the world's age. He then instituted his important experiments to determine the conductivity of rocks *in situ*, and found the value 400 (more or less), the units being a foot a year, and a degree Fahr. But it was necessary, for his calculation to succeed, that he should assume the earth to be solid. If I do not misjudge him, I think he then sought for arguments to prove this point. Now, I cannot but think that the proofs of solidity on which physicists rely are by no means convincing; and if the earth is not solid, Lord Kelvin's estimates are without foundation. Moreover, it is not sufficient that the earth should be solid at the present, to which these proofs refer, but it needs to have been so from the beginning of the time to which his estimates go back.

Prof. G. Darwin, in his book on the tides (p. 237), has done me the honour of referring to my "Physics of the Earth's Crust" as if I am an arch-heretic on this question of solidity. Whether my arguments are beneath notice, or whether there is a difficulty in answering them, I do not know; but they have never been refuted, while they are held to be of decided force by some geologists, and among these by the Indian Geological Survey.

Harlton, Cambridge, September 25. O. FISHER.

### The Terrestrial Gegenschein.

I DO not know whether the phenomenon I am about to describe has ever been noticed. The circumstances under which it is noticeable must occur rarely. They are these:—

I spent some time of the summer of 1898 on an isolated mountain peak, surrounded by lower mountains whose sides were densely wooded. The result was that near the time of sunset the shadow of my own mountain peak was visible on a mountain side which might have been three or four miles distant. One evening I amused myself by watching the shadow of the peak as the sun was descending. My attention was attracted by an illumination in the direction opposite the sun so strikingly resembling the astronomical gegenschein, that at the first glance I saw in it an explanation of the latter. It consisted of a somewhat bright glow, which might be a degree or two in diameter, but which shaded off by such imperceptible gradations that a definite extent could not be assigned. A little study, however, showed an explanation. As I have said, the mountain on which the glow was seen was densely wooded. In such a case the shadows of those leaves and branches which the sun's rays first reached fell upon the interior foliage and obscured it. But an observer looking from the exact direction of the sun will see through the foliage as far as the sun's rays extend. In other words, the visible surface on which he is looking will be entirely illuminated by the sun's rays, whether this surface is formed of the outer strata of foliage or of a strata ever so far inside, which can be seen only through the crevices in the outer stratum. The shaded interior will be entirely invisible to him. But if his point of view is in a direction ever so little oblique, he will see only the outer foliage illuminated, while more or less of the interior foliage which he sees will be in the shadow. Thus the region exactly opposite the sun will be seen in its full brilliancy, while the neighbouring region will be a mixture of light and darkness. At a distance of several miles this compound of light and darkness will be fused into a single half-shade, strongly contrasting with the full brilliant light of the opposite point.

It is clear enough that we cannot have such a state of things as this in the case of the astronomical phenomena. Yet the phenomenon seems to be of sufficient interest to warrant its being placed on record. S. NEWCOMB.

### The Cause of Undercurrents.

IN NATURE of August 3, p. 316, is given a letter from Rear-Admiral Sir William Wharton, in which he states that he is diametrically opposed to my opinion about the double currents in the Straits. He says that "Admiral Makaroff considers that difference of density of the water is the primary, and, indeed I gather he thinks, the only cause of these opposing currents; but he brings no evidence beyond theoretical considerations in support of his belief"; further, in his letter, Admiral Wharton refers particularly to the double current of the Bosporus, of which I spoke in my lecture at the Royal Society of Edinburgh. I cannot leave unnoticed remarks from so distinguished a hydrographer, who, during his long work, has contributed so much to the advance of science. My researches about the Bosporus are published only in Russian, in a book named "On exchange of water between Black Sea and Mediterranean" (St. Petersburg, 1885). Should Admiral Wharton know my language, he would easily come to the conclusion that my opinion about double currents in the Bosporus are based upon the observations made in 1881 and 1882. I then invented an instrument for measuring the current at different depths, and gave the name of "fluctometer" to it. The instrument consists of a propeller revolving on a horizontal spindle. A bell is attached to the propeller, and at every revolution of the propeller it strikes twice. As water is a very good conductor of sound, the number of revolutions could be counted through the bottom of the ship (provided the ship is not sheeted with wood) at all depths to which the instrument was lowered (40 fathoms). I used to anchor in the middle of the Bosporus for a couple of days at a time, and make a series of observations every two hours. In order to obtain more detailed data, I used to take the samples of water from the same depth to which the fluctometer was lowered. Twice I used to go along the Bosporus from the Black Sea to the Marmora Sea in order to learn in what depth is the limit of two currents. In volume xxii. of the *Proceedings* of the Royal Society of Edinburgh, Plate I. shows a position of the limit of two currents, mean velocity of both currents, and specific gravity of water. In Plate II. is given a sketch of my "fluctometer."

I am sorry that the limits of this paper do not allow me to give particulars of my observations, but I believe some of my deductions, worked out from direct observations, would be interesting to English readers.

Mean velocity of the upper current, $3\frac{1}{4}$ feet per second. It varies from 0 to 10 feet per second in certain places.

Velocity of the upper current diminishes with every fathom of depth.

Limit between two currents close to the Marmora Sea is at 11 fathoms. It gradually goes down to 27 fathoms close to the Black Sea. Limit between two currents is influenced by winds and by barometrical pressure, but not very much.

Lower current has close resemblance with the river. Its velocity does not vary very much. We never found anywhere

lower current less than 1·84 and more than 3·22 feet per second. Mean velocity of the under current was 2·32.

The upper current does not everywhere occupy the full breadth of the strait. It flows in some places under the north coast of the strait, and in other places under the south coast. Lower current also does not flow over the whole breadth, and occupies a certain part of the bed of the strait. In my book I give a chart of the Bosporus, where I show direction of the upper and lower currents. A glance at that chart will show that there are places where both currents can be found, and there are places where the instrument will show the existence of only one of them, and in some places the explorer will not find either upper direct current or under current.

Difference of level of Black and Marmora Seas, calculated from difference of specific gravity of water, is 1 foot 5 inches. Mean specific gravity of water $\left(S\frac{17\cdot5}{17\cdot5}\right)$ entering from the Black Sea into the Bosporus is 1·0140. Mean specific gravity of water entering from the Marmora into the Bosporus is 1·0283.

By upper current pass 370,000 cubic feet per second. By lower current pass 200,000 feet per second. Difference between these two figures being 170,000 feet per second is due to the excess of fresh water in the Black Sea.

I hope that after reading these figures and deductions Admiral Wharton will change his opinion, and come to the conclusion that my idea about double current in the Bosporus is based, not only on theoretical considerations, but also upon direct measurement.

Admira Wharton expresses also his opinion about double current of the strait of Bab-el-mandeb, and says that "there are none of the differences of specific gravity." I may be permitted to refer to my other book, "Le Vitiaz et l'Ocean Pacifique," where I give (p. 136, plate xxvii.) specific gravity of the strait of Bab-el-Mandeb measured by myself. Examination of figures given there by me shows that there is a difference of specific gravity which produces double current in that strait.

Nobody can deny that the wind has a great influence upon the movement of surface water; but I hope that Admiral Wharton will agree with me that differences of specific gravity has also some influence upon the circulation of water in the seas generally and in the straits particularly. S. MAKAROFF.

*Ermack*, Newcastle-upon-Tyne, September 23.

## Movement of Sea-Gulls with a Coming Change of Weather.

THE suggestion that sea-gulls may have some meteorological sense would be best tested by inquiry as to whether there was, at the time of their westward flights, observed by your recent correspondents, any other possible motive for their journeys; and particularly what food was available in the Channel at the time.

Neither of your correspondents needs to be told that every sea-gull is a semaphore to every other sea-gull in sight of him, nor that one gull "working on" fish will presently be surrounded by others from all sides.

In clear, fine weather the news of abundant sprats would be passed along the Channel in this way, faster than by military signallers, and answered by a concentration of gulls much speedier than any possible to troops.

Moreover these birds, and vultures, as I know from repeated observation, do not merely *follow each other* round the headlands. If a gull in a bay sees another gull hurrying from the offing into the next bay, he does not fly round the headland between, but rises over it, well knowing that from the upper air he will see whatever hurried the outer gull. As he does so his motions will be observed, and probably acted on by others further within the first bay; and if food be failing in the Thames, and abundant off the Wight, there will be plenty of gulls flying across Kent, and some across even Surrey. Here in Chelsea I seldom see large gulls on the river. But it is a common enough thing to see them flying high overhead to the south-westward.

Westerly and south-westerly gales are so common in the Channel that neither beast nor bird can make any movement without a good off-chance of finding one on his way. It has to be remembered that most of our migratory sea fish are apt to run *up* Channel in the warm half of the year, so that the message, "Plenty of fish on the surface," is probably most often passed from west to east.

We shall, I think, need a good many simultaneous observations at various points and of various matters before we make it even probable that sea-gulls can foretell a south-west wind, and will then go to meet it. They cannot eat it; and, if strong, it will give them little leave to eat anything else; so the motive is not apparent. W. F. SINCLAIR.

102 Cheyne Walk, Chelsea, S.W., September 22.

## On the Use of the Fahrenheit Scale for Observations on Sea Temperatures.

IN addition to the Fahrenheit scale being so much more practical for observation in meteorology than the Celsius, allow me to point out that in observations for ocean temperature it is even more so, and especially when we come to deal with observations taken in the polar regions. Here with the Fahrenheit scale we have never to deal with a minus reading at all; whereas with the Celsius scale it is a constant change from plus to minus and minus to plus. This introduces a source of very serious error both in observation and calculation, besides adding to the work, and therefore the cost of working up results. The boon of never having to think of a minus in such work is not to be lost sight of for the sake of fashion. As one who has taken part in extensive observation and calculation work at Ben Nevis Observatory, on board ship, and in connection with the Scottish Fishery Board, I would also urge the use of the Fahrenheit scale for meteorological observations on the same grounds as Mr. J. Y. Buchanan and Mr. H. Helm Clayton.

Joppa, Edinburgh, September 25. WILLIAM S. BRUCE.

## Cave Shelters and the Aborigines of Tasmania.

I HAVE just received news from Mr. J. B. Walker, of Hobart, of the discovery of some interesting relics of the aborigines of Tasmania. Mr. Walker accompanied Mr. R. M. Johnston, the Government Geologist, on an expedition in search of some remains of Tasmanians, and the party were rewarded by finding a hitherto unknown so-called quarry where the natives manufactured some stone implements, also a cave which showed considerable evidence of having been used by the aborigines, as well as a tree notched by them for climbing purposes. The sandstone cave or rock shelter i situated in Hutton Park, near Lovely Banks. The quarry is situated at Coal Hill, two miles north of Melton Mowbray, about 40 miles N.N.W. of Hobart, and 1100 feet above the sea-level.

The discovery of this quarry makes the tenth known quarry used by the aborigines, and the first mention of their use of cave or rock shelters. H. LING ROTH.

Halifax (Yorks.), September 27.

## The Darjeeling Disaster.

UNUSUALLY large seismograms were obtained in the Isle of Wight on September 3, 10, 17, 20 and 23. The first three refer to disturbances originating in Alaska. The fourth refers to disasters in Asia Minor, and the last to an earthquake having an origin as distant as Japan. Since the 23rd in the Isle of Wight, and I believe also at Kew, not the slightest movement has been recorded. The inference is that the great earthquakes reported as having taken place at Darjeeling on the night of September 25–26 are at the most small and local, and are not likely to have been recorded outside the Indian Peninsula. It is extremely likely that the tremors noticed in Darjeeling were due to landslides, and seismic phenomena were entirely absent. J. MILNE.

Shide Hill House, Shide, Newport, Isle of Wight, September 27.

## Lectures at the Royal Victoria Hall.

I SEE in your issue of September 21 (p. 513) the statement that I am to lecture at the Royal Victoria Hall on "Photographs taken in the dark." I beg to say that the title I gave for my lecture was "Pictures taken on a photographic plate in the dark." I suppose the authorities at the Hall consider the titles identical. I do not. W. J. RUSSELL.

St. Ives, Ringwood, Hants, September 26.

### Vole.

I think Nature should take note of a short article by Prof. Skeat in the number of *Notes and Queries* for September 16, wherein he points out that *vole* is corrupt Norwegian for field, and that therefore a water-vole is a water-field, a field-vole a field-field, and a bank-vole a bank-field.

Exeter. James Dallas.

## THE INVESTIGATION OF THE MALARIAL PARASITE.

Pending the arrival here of Major Ross and part of the Malaria Expedition connected with the Liverpool School of Tropical Diseases, which is expected about October 7, we may, from information already to hand, forecast some points in his report without in any way detracting from the interest with which it will be received.

In the issue of this journal for September 7 we recorded the fact that a species of Anopheles was found to be concerned in the transference of all the forms of malaria. In the barracks of Wilberforce, a suburb of Freetown, Sierra Leone, out of four hundred men there was a daily average of forty ill in hospital with all three forms of malaria. The place seems to have been infested with mosquitoes, but only the genus Anopheles was found, and of those examined one-third were found to contain zygotoblasts.

In searching for the haunts of the Anopheles larvæ the members of the expedition found them chiefly in small stagnant pools in which green algæ were growing. The larvæ appear to live upon this, for larvæ hatched from eggs did not grow unless they were given some of the algæ to feed upon. They infer that the conditions under which algæ will grow, namely, in stagnant puddles, are the same as those under which Anopheles larvæ will hatch out and thrive; the larvæ of Culex were found in every receptacle for stagnant water, even in old sardine tins. Stagnant puddles are only found during the rains on low-lying ground, and near a stream or spring, from which they can be replenished in the dry season. So far, only one experiment on the action of kerosene oil on larvæ has been reported; one drachm of the oil was poured on the surface of a pool of water of about a square yard in area, and all the Anopheles larvæ it contained were found dead after six hours.

Ross considers the Anopheles to be the genus concerned in propagating malaria, and seems to rely on being able to exterminate them from a locality to free it from the disease.

Koch (*Erster Berichtüber die Thätigkeit der Malaria Expedition*, April 25 bis August 1, 1899) found *Culex pipiens* to be concerned in propagating malaria in Tuscany, but to a lesser extent than the Anopheles. The German Commission find that the parasite requires a temperature of 80° F. to develop in the mosquito, and it is only found in these insects during the summer months. At the commencement of the hot weather the mosquito draws the parasite with the blood from a patient who has a relapse. Human beings with the parasite in their blood they consider to be the connecting link during the nine months of the year when the temperature does not allow of the parasite developing in the mosquito: they think relapses can be stopped by the use of quinine; so by this means it would become possible to stamp out the disease.

It is evident we want a large series of observations made in different parts of the world, for, if the genus Culex can propagate the disease, it would be almost impossible to exterminate these if they breed wherever water lies. On the other hand, should relapses of fever be prevented by a proper use of quinine, malaria would not be stamped out in countries where the temperature is sufficiently high all the year round to allow the parasite to develop in the mosquito.

## MR. PERCY S. PILCHER.

Many of our readers who were acquainted with Mr. Percy S. Pilcher, and others who have only heard of him through his great enterprise and keenness in constructing and using aërial machines, will be very sorry to hear that his accident on Saturday last has proved fatal, and that he died at 2.40 on Monday morning.

Mr. Pilcher, during the last few years, had been making a considerable number of experiments with the object of constructing a soaring machine which would propel itself. The writer of this note was present at one of his trials in August 1897, at the time when he was at work in designing a small light engine for propelling his machine, and communicated to this journal an account (with illustrations from photographs) of his experiments on that occasion (Nature, vol. lvi. p. 344).

Like his forerunner Otto Lilienthal, Mr. Pilcher has come to the same sad end, and now his name must be added to that already long list of pioneers in aërial navigation.

The experiments causing the fatality took place on Saturday last at Stanford Hall, the seat of Lord Braye, near Market Harborough.

We gather from the *Times* that after several ineffectual attempts to start, a signal was given about twenty minutes past four, and Mr. Pilcher rose slowly in the machine until he had travelled about 150 yards, and had risen to a height of about 50 feet or 60 feet. Then a sharp gust of wind came and the tail of the apparatus snapped. Instantly the machine turned completely over and fell to the earth with a terrible thud, Mr. Pilcher being underneath the wreckage. His devoted sister was one of the first to reach the scene of the accident. Mr. Adrian Verney-Cave, Mr. Everard Fielding, and Dr. Stuart, all friends and companions of Mr. Pilcher, removed him from the machine and found that he was unconscious. Raising his left leg it was discovered that it was fractured above the knee. Mr. Pilcher was carried to his room in the house, and Dr. Stuart and Dr. Nash carefully examined him, another surgeon being summoned by telegraph from Rugby.

W. J. S. L.

## NOTES.

Prof. Simon Newcomb has been elected president of the recently established Astronomical and Astrophysical Society of America. The secretary is Prof. G. C. Comstock.

The seventh International Geographical Congress began a series of successful meetings on Wednesday, September 27, at Berlin. Papers have been read by, among others, the Prince of Monaco, on his Greenland Deep-sea Expedition, and Dr. Nansen, on "The Hydrography of the Polar Sea." At one of the sittings of the Congress a telegram was read from Mr. H. J. Mackinder, the Reader of Geography at Oxford, announcing that he had succeeded in reaching the summit of the hitherto unscaled Mount Kenia in British East Africa, and that some fifteen glaciers were found upon the mountain. It will be remembered that Mr. Mackinder left England in June last in charge of an exploring expedition.

A buoy bearing the inscription "Andrée's Polar Expedition," found on the north side of King Charles Island, north-east of Spitsbergen, 80° latitude and 25° east of Greenwich, on September 11, has been brought to Stockholm and there opened in the presence of several experts and Ministers. It was found to be the so-called "North Pole buoy" which the explorer was to have dropped when passing the North Pole. So far as the examination extended no message from the explorer was

revealed. Prof. Nathorst declared that the buoy could not have been carried from the Pole to King Charles Island, and Captain Svedenborg was of opinion that it had been thrown out empty. A search is, it is stated, to be made next year at King Charles Island.

A MARBLE bust of Prof. Emil Du Bois Reymond has been presented to the Physiological Institute of the University of Berlin by the professor's widow.

THE new Paris Institute of Biological Chemistry, facing the Pasteur Institute, towards the erection and endowment of which Baroness Hirsch gave 80,000*l.*, is now, so far as the exterior is concerned, completed.

PROF. R. BURCKHARDT, of Bâsle, and Prof. V. Uhlig, of Prague, have been elected members of the Academy of Sciences of Halle.

THE death is announced, at the age of forty-five, of Dr. Kowalowsky, professor of hygiene in the University of Warsaw, and of Canon Carnoy, professor of the natural sciences at the University of Louvain.

IN connection with the Glasgow Lecture Association a special science lecture will be given to school children during the Christmas holidays by Prof. McKendrick, F.R.S.

PROF. GEORG STEINDORFF, the director of the Aegyptologische Sammlung at Leipzig, has, it is stated, obtained leave of absence for six months to enable him to undertake a scientific journey to Africa.

DR. L. A. BAUER, of the U.S. Coast and Geodetic Survey, is at present in Europe for the purpose of inspecting various magnetic observatories and the comparison of the Coast and Geodetic Survey instruments with observatory standards.

THE announcement is made that Mr. W. H. Twelvetrees has been appointed geologist to the Government of Tasmania. During recent years Mr. Twelvetrees has devoted considerable attention to the geological formation of Tasmania, with special reference to mining operations, and has been a frequent contributor of papers to the Australian Institute of Mining Engineers and to the Royal Society of Tasmania.

THE Corporation of Glasgow has just appointed Dr. R. M. Buchanan bacteriologist to the city. He will devote the whole of his time to the duties of the office, and a laboratory has been assigned to him in the Sanitary Chambers.

IT is announced in the *Pioneer Mail* that Mr. Douglas Freshfield has arrived at Darjeeling, accompanied by two Swiss guides, intent on exploring the great snowfields of Kinchinjunga.

THE tenth International Congress of Hygiene and Demography will be held in Paris from August 9 to 17, 1900.

THE second International Congress on Hypnotism will be held in Paris from August 12 to 16, 1900, under the presidency of Dr. Jules Voisin. The questions proposed for discussion are: (1) The formation of a vocabulary concerning the terminology of hypnotism and the phenomena connected therewith; (2) the relations of hypnotism with hysteria; (3) the application of hypnotism to general therapeutics; (4) the indications for hypnotism and suggestions in the treatment of mental disease and alcoholism; (5) the application of hypnotism to general pædagogy and mental orthopædics; (6) the value of hypnotism as a means of psychological investigation; (7) hypnotism in relation to the (French) law of November 30, 1892, as to the practice of medicine; (8) suggestion and hypnotism in relation to jurisprudence; (9) special responsibilities arising from the practice of experimental hypnotism.

IN compliance with the request made by Russian men of science to the Russian imperial authorities, the scientific exploration of the coast-line of the Pacific in the Far East is to be undertaken. It has been arranged that a distinguished zoologist and member of the Imperial Russian Geographical Society shall undertake the exploration at the cost of the Society, in conjunction with the Ministry of Agriculture. The expedition intends to make investigations with a view to classifying the marine fauna and flora on the coast of the Russian territory, and the conditions of zoological life will also be investigated upon the Liao-Tong peninsula, and in the adjacent regions of Manchuria and Korea. The period for these investigations has been fixed at two years, and the cost of the expedition is estimated at 12,000 roubles. The Geographical Society has promised to make a grant of 7500 roubles towards this sum, and the Ministry of Agriculture and Imperial Domains will contribute the remaining 4500 roubles. The Ministry of Agriculture has been led to take a part in this expedition in the expectation that its results will be of great service in developing the coast industries of the Amur and the Island of Saghalien, and also in the districts which have been acquired lately by the Russian Government. The Geographical Society also entertains great hopes of the successful results of this expedition, in view of the fact that the previous expeditions sent by it to investigate the Black, Azov, and Marmora seas were particularly successful. The expedition to the Far East will work in conjunction with the Society for Exploring the Amur Territory, and intends to establish at Vladivostock a zoological station for studying the marine fauna of the district.

*Science* states that the late Richard B. Westbrook, of Philadelphia, has made a bequest of 10,000 dollars, taking effect on the death of his widow, to the Wagner Institute of Science. The sum is to be used as an endowment of a special lectureship to "secure the full and fearless discussion by the most learned and distinguished men and women in our own and other countries of mooted or disputed questions in science, and especially the theories of evolution."

A YEAR ago Cornell University secured 30,000 acres of woodland in the Adirondack Mountains for the exclusive use of the University's forestry department. The land has been divided into a number of sections, and several seed beds have been laid out in which there has been planted over a million small trees of different varieties. The students of forestry will study the theory of the subject from October to April, and from then until Commencement they will study the practical side of forestry. Cornell University is, according to the *Scientific American*, the only college in the United States which has a forestry department.

THE *Scientific American* states that the men of science who have been investigating the Wyoming fossil beds are having remarkable success, and a large number of boxes containing fossil remains have been sent to the State University, and the work of restoration will soon be begun under the direction of Prof. Wilbur C. Knight.

DURING this summer a number of field parties in connection with the United States Fish Commission have been engaged, in various States, in ichthyological and other investigations. A camping party under the direction of Dr. Charles H. Gilbert has, says *Science*, systematically examined the coastal streams of Oregon, with reference to their fish fauna; the eastern tributaries of the Sacramento have been visited by Mr. C. Rutter; a comprehensive study of the biological and physical features of the Wabash basin has been begun under the direction of Prof. B. W. Evermann; a party in charge of Mr. W. P. Hay has explored the Monongahela basin in West Virginia; Dr. P. H.

Kirsch has been collecting and studying the fishes of the San Pedro River, Arizona; in connection with the biological survey of Lake Erie, Prof. J. Reighard and assistants have cruised along the northern and southern shores of the lake in a special steamer; Dr. H. M. Smith has visited Seneca Lake, N.Y., for the purpose of determining the character of its fish fauna; a study of the variations of the mackerel of the east coast has been conducted by Mr. M. C. Marsh, and in the interesting Sebago and Cobbosseecontee lake regions of Maine, Dr. W. C. Kendall has made some special investigations regarding salmon and other fishes.

THE return of the schooner *Julia E. Whalen*, after an absence of nearly a year, is announced in *Science*. The vessel was sent out by Stanford University on a scientific cruise among the Galapagos Islands, &c., and carried members of a scientific expedition under the direction of R. E. Snodgrass, entomologist, and E. Heller, zoologist. A large collection of specimens, including birds, mammals, invertebrates, and fish, was obtained. On board the vessel were eighteen live land tortoises taken from Duncan and Albemarle Islands, some of them weighing four hundred pounds; also 220 fur sealskins and 2300 skins of hair seals.

A REMARKABLE demonstration of the success of inoculation against the plague is to be found in the statement recently made to the Indian Imperial Research Laboratory by Dr. Chinoy, the medical officer of the Southern Mahratta Railway at Hubli. In Hubli itself 4961 persons were inoculated once, 7840 persons twice, and 1346 persons thrice (these having been twice inoculated last year), or a grand total of 14,147. In the district 1849 persons were inoculated once, and 1967 twice, or altogether in Hubli and the district a total of 17,963 persons. In the words of Dr. Chinoy: "There are about 1000 people living in the railway chawl, Hubli, which was seriously infected last year. *All of them are inoculated*, and I am glad to be able to state that *not a single case of plague* has occurred amongst them since plague broke out in the town, although they freely move about and mix with people in the town, where plague is increasing daily."

THE report of the Imperial Bacteriologist at Calcutta for 1898–99 states that a considerable quantity of mallein and tuberculin are being manufactured in the laboratory for veterinary use. The hope is expressed that arrangements may be made for dairy and other cattle to be tested with tuberculin, so as to ascertain the extent of tuberculosis amongst cattle in India. Attention has been given to the further investigation of "surra," and the report says it is more than ever probable that this disease is identical with the South African tsetse-fly.

THE Vienna correspondent of the *Times* reports some experiments in a new system of telegraphy made in Budapest and Berlin on Friday last. These are alleged to have given the extraordinary result of a transmission of no fewer than 220 words in ten seconds without prejudicing the clearness of the message. According to the reports from Budapest, the impression made upon the technical experts who had an opportunity of following the trial was favourable. A perforated roll of paper, similar to that at present in use, is employed for the despatch of the message, which is made visible and fixed photographically at the receiving station. Instead of the dashes and dots of the Morse alphabet there are rising and falling strokes starting from a horizontal line. The receiver consists of a telephone fitted with a small concave mirror, upon which are reflected, in the form of streaks of light, the impulses marked on the membrane. By an ingenious arrangement, recalling in some respects that of the cinematograph, the streaks of light reflected upon the mirror are reproduced upon a roll of sensitised paper, thus giving a narrow oblong picture, which in the present stage of the invention is developed and fixed like any ordinary photograph.

THE fumigation of trees for the destruction of insect pests has for some time been extensively used in California and other parts of the United States. The process will probably soon come into use in New South Wales, for Mr. W. J. Allen describes in the *Agricultural Gazette* of the Colony some very successful experiments in spraying and fumigating for red and other scales on orange trees. The tree to be treated is completely covered with a tent, such as is shown in the accompanying illustration, and is subjected for nearly an hour to the fumes of hydrocyanic acid, produced by the combination of sulphuric acid and potassium cyanide. The number of men generally employed in a fumigating gang is four or five, according to the size of the trees. One man introduces the chemicals, another looks out for the generator and measures the acid, and

Placing tent over tree to be fumigated.

two or three handle the tents. Such a gang can handle from thirty to forty medium-sized tents, and cover four to six acres of orchard in a night. Fumigation is to be preferred above spraying, because the trees are not in any way damaged by the fumes, except in the case of a few of the tender leaves, while the solution used in the sprays must to a certain extent close the pores of the tree and slightly weaken it.

ACCORDING to the *Engineer*, the signalling on the whole of the Pennsylvania Railroad system is now operated electrically. When a train passes a signal bridge it closes an electric circuit, which moves a signal semaphore to the "danger" position. When the train passes beyond the next bridge a circuit is opened, and the signal indicates that the block from which the train has just passed is clear. Finally, when the train passes beyond the third bridge, another signal arm on the same post drops, showing the driver of an approaching train that there is nothing on the next two blocks ahead.

THE connection between fleas and the permanency, or otherwise, of continents might not at first sight be very apparent, but, nevertheless, some important evidence on the latter point is afforded in a paper by the Hon. N. C. Rothschild published in *Novitates Zoologicae* for December last. In this contribution the author, who is making fleas his special study, describes a new species of those insects on the evidence of a single specimen from Argentina, which is believed to take up its abode on a rat. Now this Argentine flea, which is remarkable on account of the helmet-like shield covering the head, is provisionally assigned to a genus (Stephanocircus) hitherto represented by a single Australian species infesting the spotted dasyure (*Dasyurus maculatus*). And we presume it may be taken for granted that, whether or no they are rightly regarded as congeneric, the two species are evidently very closely allied. Now this being so, it is difficult to see how they reached their respective habitats except by means of a direct land connection between Australia and South America; and they accordingly serve to confirm the evidence afforded by the occurrence of the chelonian genus Miolania in both areas, to which attention has been recently drawn in these columns.

THE discovery of a new generic type of marine gastropod, represented by a species whose shell is over six inches in length, is such a rare event, that Mr. G. B. Sowerby's description of *Neptuneopsis gilchristi*, from the Cape seas, demands a brief notice. In general form the shell (which is described in the publications of the Cape Department of Agriculture for 1898) is so like some of the *Buccinidae*, such as *Neptunea* (*Chrysodomus*) that, were it not for its curiously swollen apex, it might be referred to the genus mentioned. On the other hand, the tricuspid tooth-ribbon, or radula, is of the characteristic volute type; and Mr. Sowerby consequently infers that the new genus should be placed in or near the *Volutidae*. If included therein, it will represent an interesting annectant, and therefore generalised type. The generic name selected scarcely seems to us a happy one.

THE close study of the smaller mammals of Europe on the lines followed by the American naturalists for those of their own country is gradually bringing to light the existence of numerous local races of species hitherto quite unsuspected. A remarkable instance of this is Mr. Barrett Hamilton's recognition of two new forms of mice from St. Kilda, which are described in the June number of the *Proc. Zool. Soc.* The first of these (*Mus hirtensis*) is nearly allied to the wood mouse (*M. sylvaticus*); while the second (*M. muralis*) is as closely related to the common house mouse. The former the author regards as indigenous to St. Kilda since the period when that island was connected with the mainland; while the latter he considers to have been derived from individuals of *M. musculus*, introduced by human agency not more than a few hundred years ago. Yet both differ from their mainland prototypes to the same degree; and thus indicate the different inherent variability of different species. The variation displayed by *M. muralis* is probably in the direction of the wild ancestor of *M. musculus*.

IN the *Indian Meteorological Memoirs*, vol. vi. part v., Mr. Eliot contributes a very important discussion of the air movement at Simla and in the Western Himalayas, deduced from anemometric observations recorded at Simla during four years ending August 1896. Some fifty years ago Sir Richard Strachey made a lengthened series of observations, chiefly in Kumaon, and in his description of the diurnal variation of the wind he considered the most important feature of the air movement in the Western Himalayas to be the up and down valley winds. Mr. Eliot's discussion entirely confirms this view. He states that the examination of the wind data from every point of view shows that the most important and unique feature of the air movement is the alternating currents between the hills and plains. He states that it is a permanent feature, independent of the change of seasons, and also of the air movement in the plains of Northern India, and is due to the changes of pressure vertically produced by the unequal expansion and contraction of the lower and middle strata of the atmosphere over the plains of Upper India and the Western Himalayan mountain zone.

THE *U.S. Monthly Weather Review* for June contains particulars of the increased usefulness of the Canadian Weather Service. For the year 1896 (the last published) the Report consists of two large quarto volumes, instead of one octavo volume published a year or two previously. During that year there were more than three hundred stations of observation of various classes. At the chief stations (eight in number), the telegraphic reporting stations, and a few of the special stations, the observers are paid, but the great bulk of observers are volunteers. There are thirty telegraphic stations, whose reports are received in Toronto before 9.30 a.m., and which, combined with fifty-four reports received by exchange from the United States, enable the director at Toronto, Prof. Stupart, to issue daily weather maps and forecasts similar to those published by other meteorological offices. The second volume is wholly taken up with details and results of the observations made at the eight chief stations. For each of these the Report gives for every hour and day the complete record of all the principal meteorological elements, in a form closely corresponding to that recommended for international meteorological publication of detailed observations. Prof. Cleveland Abbe's comment upon the work is that it is a noble contribution of data needed for the study of climatology in its relation to every matter that interests civilised humanity.

AN investigation of the emission and absorption of platinum-black and soot, and their dependency on the thickness of the layer employed, forms the subject of a paper by F. Kurlbaum in *Wiedemann's Annalen* (67). It would appear that both substances closely approach a black body in their behaviour towards waves of the length emitted by a black body at a temperature of 100°. For shorter waves the power of absorption increases. Both platinum-black and soot satisfy the Stefan-Boltzmann law when a sufficiently thick layer exists at high temperatures; and any deviations from this law are due to the radiating surface, or the bolometer being too thinly coated. Several further results of interest are found, and the author considers that for several reasons platinum-black is better than soot in all experiments.

IN the *Transactions* of the Institution of Mining Engineers, M. A. Rateau, Professor at the School of Mines, St. Etienne, describes experimental investigations on the theory of the Pitot tube and Woltmann mill, which are employed by engineers in gauging the rate of flow of air and water. Although the Pitot tube and mill and fan anemometers measure accurately the velocity of currents when these currents are uniform, they give, under opposite conditions which usually prevail, indications of the mean velocity which are always exaggerated, and are the more exaggerated the more marked the irregularity of the current itself. M. Rateau finds that the equation $v = a + bn + c/v$ which holds for low velocities in connection with such meters should, for velocities unrestricted in magnitude, be written in the form $bn = v - c/v - f(v)/v$, where $f(v)$ is a function of the resistance of the fluid with regard to which our knowledge is still somewhat deficient. In a note added later attention is drawn by the author to subsequent experiments by Mr. Epper, bearing on the same subject.

As there are insufficient data on the normal relations of voluntary movement to consciousness, Dr. R. S. Woodworth

has set himself to this study, and his results are published as a monograph—"The Accuracy of Voluntary Movement"—in *The Psychological Review* (vol. iii. 1899). The following are some of his conclusions: When the eyes are used, the accuracy of a movement diminishes as the speed increases; but it does not vary so much when the eyes are not used; the right hand is slightly more accurate than the left. When the interval between successive movements is kept constant and the speed of the motion alone varied, the accuracy diminishes rapidly as the speed increases, the accuracy also diminishes on keeping the speed constant and varying the interval alone; the accuracy of initial adjustment is favoured by a short interval, accuracy of current control by a low speed; fatigue increases the variability of a performance, but practice decreases it, variability means improvability. Finally, the author advocates a new mode of writing, as he finds that the side to side movement of the wrist and forearm possesses advantages in point of ease and of speed over the usual thumb-and-finger movement, or a movement of the whole arm from the shoulder.

Dr. Mario Baratta has contributed a preliminary sketch of his work on the Latian earthquakes to the *Rivista Marittima* for August. He shows that the more important shocks are connected with certain definite seismic centres, the positions of which he determines. An interesting comparison is made between the earthquakes of an extinct volcanic region, such as the Alban Hills, and those which precede, accompany and follow an eruption of an active volcano such as Etna. In both, the disturbed areas are as a rule extremely small, and yet near their centres the shocks may be strong enough to damage buildings. Also, in successive shocks, there are many changes in the positions of the epicentral areas.

M. A. de Gramont sends a reprint of an article describing a method he has devised for varying the scale and dispersion of a laboratory spectroscope (*Comptes rendus*, vol. cxxviii., p. 1564, June 1899). The scale is adapted in the usual way by placing it at the end of a collimator tube and arranging that the light from the scale shall be reflected from one face of the prism into the observing telescope; but instead of having only one lens in the scale tube, fixed at its principal focus from the scale, there are two lenses there, whose distances from each other and from the scale can be varied by known amounts. It will be at once apparent that the effect of this will be to alter the magnification of the scale as seen in the observing telescope, and in practice the scale is so altered that a certain number of divisions always correspond to the distances between the same two spectrum lines, whatever kind of prism or dispersive arrangement is being used. The variation in the dispersion is obtained in a well-known but little used manner, by rotating the prism about its refracting edge, and using positions more or less removed from that of minimum deviation, the dispersion being increased or decreased accordingly as the prism is turned towards the collimator or telescope from the mean position. A useful diagram is given bringing together the various effects on the dispersion by gradual displacements of the prism. The author is investigating more closely the variation of dispersion with the angle of incidence, and will communicate results later.

An observation of some interest in connection with recent discussions on heredity is recorded by M. Casimir de Candolle in a paper read before the *Société de physique et d'histoire naturelle de Genève*. He points out a constant difference between the normal and the adventitious buds of trees. The latter he regards as new individuals of the same species as the tree from which they spring, or as apogamic embryos, while the former are simply organs for prolonging the life of the individual. It is quite common for the first leaves of a woody plant to differ in form or structure from the later leaves. Examples are given in *Eucalyptus globulus*, the walnut, the horse-chestnut, and the hornbeam. In all these cases the first leaves from adventitious buds resemble, not those from normal buds, but the first leaves of the young plant.

A second edition of Dr. M. M. Richter's tables of carbon compounds is in course of publication by the firm of Leopold Voss, Hamburg and Leipzig (London: Williams and Norgate), under the revised title of "Lexikon der Kohlenstoff-Verbindungen." How tremendous has been the advance in the knowledge of carbon compounds since the original work appeared may be judged by the fact that the total number of compounds registered in the new edition is 67,000, as compared with 16,000 known in 1883. The work will be an index to Beilstein's handhook of organic chemistry, for all the compounds—about 57,000—contained in Beilstein are dealt with. Papers published up to the end of last year have been used in the preparation of the volume, and it is intended to publish annual supplements in order to keep the work up to date. The "Lexikon" will be completed in about thirty-five parts, twelve of which have been issued.

Messrs. Whittaker and Co. have published a second edition, thoroughly revised, of "An Introductory Course of Practical Magnetism and Electricity" by Mr. J. Reginald Ashworth. The book contains an admirable course of experimental work suitable for students in "Schools of Science" and other institutions where physics is taught by laboratory practice. A number of new illustrations have been added to assist students to understand descriptions of experiments.

Calendars, for the session 1899–1900, have reached us from the Merchant Venturers' Technical College, Bristol, and the Birkbeck Institution, London, in each of which all necessary information is to be found as to the various activities in connection with the two institutions. We notice that at the Merchant Venturers' College certain extensions and improvements have recently taken place; *e.g.* a new optical laboratory has been opened in connection with the Department of Applied Physics and Electrical Engineering, the amount of space available for the dynamo and testing-room has been doubled, and a battery, &c., have been added to the equipment. In addition to these, other changes have either taken place or are in progress.

Two articles of scientific interest are to be found in the current issue of the *Humanitarian*—one, by Mr. E. W. Brabrook, entitled "Anthropology, 1863–1899"; the other, by Dr. D. Somerville, on "The Rise of Bacteriology." Each gives in brief outline some idea as to what has been accomplished in the two branches of science. A reproduction of a striking photograph of Mr. Brabrook forms a frontispiece to the number.

We are asked to say that the lectures to young people, referred to in the last issue of Nature, p. 538, are to be delivered by Mr. Cecil Carus-Wilson during the months of October and November, and not as was stated.

The additions to the Zoological Society's Gardens during the past week include five Barbary Turtle Doves (*Turtur risorius*) from Africa, presented by Mrs. J. A. Moore; one Ruffed Lemur (*Lemur varius*) from Madagascar, two Westermann's Eclectus (*Eclectus westermanni*) from Moluccas, a Two-spotted Paradoxure (*Paradoxurus binotata*) from West Africa, a Rufous Tinamon (*Rhynchotus rufescens*) from Brazil, a Grey Ichneumon (*Herpestes griseus*) from India, four Blanding's Terrapins (*Emys blandingi*) from North America, deposited; a Black-necked Swan (*Cygnus nigricollis*) from Antarctic America, a Hoopoe (*Upupa epops*), two Sandpipers (*Tringoides hypoleucus*), European, two Lanceolated Jays (*Garrulus lanceolatus*) from the Himalayas, purchased.

## OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL OCCURRENCES IN OCTOBER:—

October 7. 10h. 18m. Minimum of Algol ($\beta$ Persei).
9. 14h. Saturn in conjunction with the moon (♄ 1° 27′ N.).
10. 7h. 7m. Minimum of Algol ($\beta$ Persei).
10. 7h. 3m. to 8h. 10m. Occultation of 4 Sagittarii (mag. 4·6) by the moon.
11. 5h. Mars in conjunction with Jupiter, ♂ 1° 11′ S.
14. Vesta (mag. 6·5) in opposition to the sun.
15. Venus. Illumination portion of disc 0·991; Mars, 0·981.
16. 6h. 3m. to 7h. 2m. Occultation of 16 Piscium (mag. 5·6) by the moon.
16. 11h. 53m. to 13h. Occultation of 19 Piscium (mag. 5·2) by the moon.
18–20. Epoch of the October Meteors (Radiant, 91°+15°).
21. 8h. 37m. to 9h. 35m. Occultation of $K^1$ Tauri (mag. 4·6) by the moon.
21. 8h. 38m. to 9h. 34m. Occultation of $K^2$ Tauri (mag. 5·5) by the moon.
26. 6h. Venus in conjunction with $\alpha$ Libræ. ♀ 0° 6′ N.
29. 13h. Venus in conjunction with Jupiter. ♀ 0° 33′ S.
30. 8h. 50m. Minimum of Algol ($\beta$ Persei).

COMET E. GIACOBINI.—A telegram has been received from the Centralstelle at Kiel announcing the detection of this comet at the Nice Observatory for the first time during the present apparition. The observation was as follows:—

1899. Sept. 29d. 8h. Nice Mean Time. $\begin{cases}\text{R.A. 16h. 26m. 32s.}\\ \text{Decl.} -5° \ 10'\end{cases}$

The daily motion in right ascension is + 2m. and in north polar distance − 10′, so that the comet is moving slowly in a north-easterly direction. The position at the time of discovery on September 29 was about 3° north of the 5th magnitude star, $v$ Ophiuchi. The comet is merely described as "faint." Previous appearances of this visitor took place in September 1896 and June 1898.

A later telegram from Kiel announces that the comet has been observed at the Konigsberg Observatory, the measured position being:—

1899. Oct. 1d. 8h. 0·5m. $\begin{cases}\text{R.A. 16h. 31m. 0·7s.}\\ \text{Decl.} \ -4° \ 39' \ 50''\end{cases}$

TWO NEW VARIABLE STARS.—Dr. T. D. Anderson, of Edinburgh, announces in *Astr. Nach.* (Bd. 150, No. 3594) his discovery of two new variables.

(1) *In Hercules.*—A star, not mentioned in the B.D., whose position is

$$\left.\begin{array}{l}\text{R.A.} = 17\text{h. } 53\text{m. } 27\text{s.}\\ \text{Decl.} = +19° \ 30'\end{array}\right\}(1855)$$

was found in August to have a variation amounting to about 0·9 of a magnitude. The star is about 2′ or 3′ *north-preceding* the 9·2 magnitude star B.D. + 19°·3489.

(2) *In Cygnus.*—A star, not mentioned in the B.D., whose position is

$$\left.\begin{array}{l}\text{R.A.} = 20\text{h. } 9\text{m. } 44\text{s.}\\ \text{Decl.} = +30° \ 37'\end{array}\right\}(1855)$$

is at present (September 21) rapidly diminishing in brightness. Comparisons with the neighbouring stars B.D. + 30°·3958, 3963, 3964 showed the variation in magnitude to be from 8·5 to 9·2.

THE MELBOURNE OBSERVATORY.—The thirty-third report of Mr. P. Barrachi, the Government Astronomer at the Melbourne Observatory, Victoria, has recently been distributed, showing the work undertaken and the progress made during the period July 1, 1898, to February 28, 1899. The observatory is reported in good order, the instruments well cared for and in good working condition.

With the 8-inch transit circle 1571 observations have been made in right ascension, for determinations of azimuth, clock corrections and catalogue stars; also 1017 observations in north polar distance have been made in connection with latitude determination, catalogue stars and special zodiac stars. The catalogue stars were intended chiefly to be used in the reduction of the plates for the astrophotographic catalogue. The zodiacal stars have been observed at the request of Dr. Gill, of the Cape Observatory, in connection with his heliometer observations of Neptune and the other major planets at opposition. All the reductions are well in hand.

*Astrophotographic Catalogue.*—The series of plates for the catalogue is now completed, and 387 plates for the Chart have been passed as satisfactory. Special series have been taken for the region round the South Pole, and seven plates have been exposed for the Oxford chart type. The measurement of the plates is being undertaken by six young ladies, using three micrometers. The probable error of a measured coordinate is now no more than 0″·1, which is within the prescribed limit. The progress of this part of the work is rather slow, but trials with Prof. Turner's scale, as adopted at Greenwich and Oxford, although permitting of much greater speed, showed the error to be as great as 0″·5, and therefore all the measurements are to be made with the filar micrometer. A new instrument, similar to that designed by Dr. Gill for the Cape, has been ordered from Messrs. Repsold and Söhne.

The various operations connected with the time service, meteorological observations, and inspection of outlying depôts have been carried out as in previous years.

*Terrestrial Magnetism.*—The photographic registration of the horizontal and vertical components and of the magnetic declination have been continued, absolute measurements and redeterminations of scale zeros being made *five* times. The measurement and reduction of the curves obtained since 1867, numbering some 30,000, have been commenced.

The photo-heliograph has been employed on sixteen days for solar pictures; 264 pairs of cloud photographs have been obtained with cameras placed at different points round the observatory buildings.

The great telescope and south equatorial have been used for comet and planetary observation, and for the use of visitors, 189 persons being admitted on Wednesday afternoons and 195 at night during the year.

## SIR ANDREW NOBLE ON THE BEST EDUCATION FOR ENGINEERS.[1]

WHEN your Dean first did me the honour to ask me to address you on the opening of your session, I had grave doubts as to whether I was a proper person to accept the invitation. On the one hand, I have had little or nothing to do with the education of others, and in some points my views, at all events so far as regards primary education, are at variance with much that is being done at the present day, but as, on the other hand, I have had exceptional opportunities of observing, both in this and other countries, certain points which seem to me to be of importance to those who propose to uphold the industrial supremacy of this country in the struggle which year by year other countries are rendering more and more severe, you therefore see me here to-day, and I shall consider myself amply rewarded if I can tempt but one of you to enter, for the sake of knowledge itself, the boundless fields which science day by day is opening up to you. I can promise that the pursuit will give you happiness. I hope it may give you wealth and distinction; but I remember the words of the Preacher, that riches are not always given to men of understanding, nor favour to men of skill, but that time and chance happen to us all.

Technical education is a phrase that has been so often misused, perhaps so often misunderstood, that many of those who, like myself, are engaged chiefly in trying to solve the practical problems of engineering are in the habit of hearing it either with impatience or of regarding it as a fad of lay theorists, or sometimes, I fear, as a cloak for educational shortcomings in other directions. And I am bound to confess, if their experience has been the same as mine, that there is some excuse for them. You can form but little idea of the number of persons of both sexes who have assured me that their sons had no taste for books, but had shown a marvellous talent for engineering. I need hardly tell you that the marvellous talent generally turns out to be an incapacity, possibly from defective education, for seriously applying the mind to any subject whatever.

But technical education, properly considered, is of the highest

[1] Inaugural Address of the Session 1899–1900 of the City and Guilds Central Technical College, given at the College, Exhibition Road, by Sir Andrew Noble, K.C.B., F.R.S., on Tuesday, October 3.

importance both to you and to England. It is only its abuse that we have to guard against.

Now one of the great abuses I take to be that technical education is often begun too early in life, that is, that it is substituted for a general education, and a boy attempts to put his knowledge to practical use before he has learnt how to learn.

Another abuse is the divorcing of practice from theory, and the danger of elevating practical application above scientific knowledge.

I shall try, therefore, to-day to say a few words, firstly, about the necessity of acquiring a sound general education before any special work is attacked, and, secondly, about the necessity of basing all practical work on theoretic knowledge.

I attribute the compliment which has been paid me in the invitation to speak at the opening of the present session to the fact of my having been connected, for many years past, with the management of probably the largest engineering firm in England. That position has afforded me exceptional opportunities for observing what educational antecedents are likely to produce the best results in the engineering field. I say "exceptional opportunities" advisedly, for we at present employ in our various works not far removed from 30,000 hands. Of these a large number are youths; often sons of workmen, but not unfrequently drawn from the class which I see represented before me.

I am continually asked what education I should recommend for a lad entering Elswick. I always say, "Send your son to as good a school as you can, keep him there as long as you can, do not curtail his time of schooling, do not stunt his early intellectual growth by narrowing it down to any special study as taught at elementary schools."

Science, mechanical drawing, and such like are no doubt very useful (as all knowledge is useful) in their way. These studies may prove an irresistible attraction to minds with a strong bent towards scientific subjects, but I would fancy most employers would rather that a lad came to us blankly ignorant of both, so long as he had had a good education, had been taught, and had ability to think, and to concentrate his attention on any subject brought to his notice.

Some of you may have heard, no doubt, the answer of the Duke of Wellington to a father who asked him what was the best education for his son, preparatory to his joining the army: "The best education you can give him."

It was a very pregnant utterance, terse and to the point, as nearly all the great Duke's were; and it remains as true for any other profession as for the army.

In nine cases out of ten, I should say, any knowledge acquired by a boy before he is sixteen can have but a slight intrinsic value. Up to that age, it is not *what* he learns that we have to look at, but *how* he learns; it is the habit of discipline, of mental application, of power in attacking a subject, that are so valuable; not, generally, any definite piece of knowledge he may have gained.

According to my experience, the most valuable knowledge that a man has at his disposal is that which he has taught himself. That a special technical education is not an absolute necessity is not difficult of proof My own chief, Lord Armstrong, commenced life as a solicitor; James Watt was an instrument maker, and was prevented from opening a shop in Glasgow because he had not served a full apprenticeship. George Stephenson was an assistant fireman to his father at Killingworth Colliery. Faraday was brought up as a bookbinder. I cite the cases of these great men simply to show how men without trained assistance have taught themselves, and what can be done by the dauntless energy, untiring industry and patient search after truth which were the great characteristics of all of them, and which enabled them to do such great things.

My own impression with regard to early education is that, as a sharpener of the young intellect, and as a mental discipline, it would be difficult to improve upon the curriculum which is now in force at our public schools, and which, in the main, has been in force for so many centuries.

I am not in accord with those who think that modern languages should supersede the classics as a means of education, and I should regret more than I do the attempts which have been made in this direction, did I think that these attempts were likely to be successful. Men of science will remember that practically the whole of our scientific nomenclature is borrowed from the Greek and Latin languages; and, personally, I have found my own knowledge of the classics—which represents, no doubt, that of a very ordinary schoolboy—stand by me, and enable me to enjoy, as I would not otherwise have done, that noble literature, which, as Lord Macaulay says, is the most splendid and perhaps the most durable of the many glories of England.

But, whatever may be the fate of the classics as a means, I must take up my parable against a course of education I have seen in several primary schools where an attempt is made to teach boys, often little better than children, rudimentary chemistry, rudimentary geology, also physiology and electricity.

Occasional popular lectures on these sciences may be of very great value to some boys in interesting them in these great subjects, and in leading them, at some later date, seriously to study them, but these sciences as taught in the schools I refer to can have but little value in encouraging habits of thought, of application, and of mental discipline; and to knowledge so acquired the words of Pope are peculiarly applicable:—

> "A little knowledge is a dangerous thing,
> Drink deep or taste not the Pierian spring,
> There shallow draughts intoxicate the brain,
> And drinking deeply sobers it again."

I am aware that many people say that the years a boy wastes on Greek and Latin might be better employed in learning German and French. It may be so, but it is not difficult to teach these most important languages colloquially at a very early age; and with regard to technical subjects, speaking from my own observation, I may say that I do not think I have known any man at twenty-eight or thirty who was the better for having abandoned his general education for technical subjects at too early an age.

Those men who, with fair abilities, have received a really good education, have been taught to use their minds, and who, by contact with other students, have acquired habits of application, amply make up for their late start by the power of mind and grip that they bring to their work. They are fresh and keen when others, who have been hammering away at semi-technical work from early boyhood, have become stale and are less vigorous, and that reflection moves me to deprecate strongly any attempt to teach seriously practical or electrical engineering in preparatory or elementary schools. As an excellent recreation, such studies are no doubt to be encouraged, but to make them a systematic part of education, to the exclusion of studies which have a more direct effect in developing the understanding, seems to me to be entirely wrong. I would go further and say that even in public schools, and their equivalents, for older boys, what are termed engineering shops are generally a failure, so far as any efficient knowledge to be gained in them is concerned. Except as a reasonable diversion for recreation hours, such "shops" have, I fear, but little value, and in nine cases out of ten the hours spent in them are subtracted from the time due to more valuable studies.

In my judgment, the age at which a boy should seriously begin any special studies, with a view to fit him technically for the profession he may have decided to follow, should not be earlier than seventeen or eighteen.

And in any discussion as to the age at which a boy should leave school, the great incidental advantages that he gains from a reasonable prolongation of his schooldays must never be lost sight of. A stricter discipline, a wiser supervision, a more authoritative yet sympathetic advice as to conduct, are more possible at school than can ever be the case in after life, and a more constant and generous association with his equals rubs off angularities and leads to amenity of disposition. It is seldom, indeed, that one cannot trace the difference between a lad who has had a full public school training and another who has been less fortunate. Speaking as an employer of labour, I should say that we find a pleasant speech and manner, tact in dealing with others, and some power of organisation of the utmost value; and it is precisely those qualities which a boy acquires, or ought to acquire, in his *later* years at a public school. Without such qualities even the highest scientific attainments will never make a captain of industry, and in selecting candidates for appointments the man-of-business distinctly prefers a youth who has had the benefit of some years at a good school.

So much for the necessity of grounding technical studies on the basis of a sound general education.

The next point I should like to urge is that any practical technical instruction and any practical knowledge acquired in the

workshop should be based upon sound theoretic knowledge. I am driven to enforce this question because (speaking again from my own observation) I find that in this country far too much weight is given to practical skill and what is called the "rule of thumb"; far too little to sound theoretic knowledge.

In the middle of this century English machinery was immeasurably superior to any other. To our remaining content with this state of things, and to our seriously neglecting technical instruction, I attribute the very much greater comparative progress that Germany, the United States and Switzerland have made in the last fifty years, and, if I am not very greatly mistaken, we shall have before many years, in the East, an important commercial rival in Japan, since that country is developing its manufacturing powers with an energy that is as remarkable as it is unexampled.

Turning to other departments of industry, no Englishman can observe without regret how certain branches have almost altogether abandoned this country, and been in a great measure left to those who have paid more attention to technical instruction.

Nearly every requirement of a drawing office can be better and more economically obtained from Germany. From what source do all our pure chemicals come, our filter papers and most of our glass apparatus? I admit that the workmanship of many articles made in England cannot be surpassed, but if we require any original or special piece of apparatus we are frequently compelled, as I have been, to go to Germany or France for their manufacture.

I do not desire to press my point too far, and admit that a portion of this transference of work, which I so much regret, may be due to cheaper labour. But the English mechanic is second to none, and if that false trade unionism, which endeavours to prevent the most intelligent and skilled from reaping the full benefit of their abilities, be abandoned, I do not despair of seeing this country regain much that it has now lost.

But it is to theoretic and technical knowledge that we must chiefly look. Consider, as an illustration, electricity in the service of man. Think of its innumerable applications, and of the number of hands dependent upon its industries. But for one man capable of designing or improving these powerful machines or delicate instruments, there are a thousand ready and able to carry out their designs. But it is the former who are the salt of the earth, and those who have the management of large concerns know well how to value them.

It was to meet the want that I am referring to that your Technical College was founded. Its objects are admirably stated in its programme, and your attention is drawn to the undoubted fact that no theoretic or technical instruction can supersede the necessity of obtaining practical experience in the workshop and factory. But, on the other hand, I believe that no genuine success in the higher walks of industry is probable without thorough theoretic or technical knowledge.

In my experience I do not think I have ever known a man rise to the top of the tree without it. I may, perhaps, be forgiven if I refer to one great engineering genius, Lord Armstrong, with whom it has been my privilege to be so long and so intimately connected. In whatever investigation he was engaged, he added to sound theoretic knowledge an intensity of application and an apparently intuitive perception of the results to be expected that I have rarely seen equalled.

Of him it may be truly said that "whatever his hand found to do, he did it with his might."

Sir William Harcourt, speaking a fortnight ago, attributed the immense commercial advance which has recently been made by Germany to the better teaching of languages, and to the German merchant being able to speak to the English buyer in a tongue which he can understand. I very much doubt if that has much to do with the matter, and I am sure that houses where business is done on a large scale very much prefer that all letters should be in the languages of the respective writers, and not in the doubtful English that is not unfrequently thrust upon us. There is no doubt that Germany is competing with us, as she has a right to do, successfully; and, so far as I am aware, with respect to her manufactures, perfectly honestly.

I say "honestly," because I do not believe in any attempt to enhance the value of one's own wares by depreciating those of other people; and I entirely differ from those who would attribute the success of our German competitors to their putting on the market inferior goods specially got up to imitate those of a superior class. It was some idea of this kind, no doubt, that led to the most ill-advised regulation that foreign-made goods should be stamped so as to show their origin. It doubtless does this, but its effect is, I believe, in the direction of an advertisement for foreign goods, and there is some danger that if our own manufacturers relax their efforts the "made in Germany," which was, I think, meant to be a reproach, should become, on the contrary, a hall-mark of excellence, as when the *Wilhelm der Grösse*, one of the finest steamships afloat, steamed into Southampton water with a facetious placard, "Made in Germany," hanging on her side.

In many articles, and especially with the apparatus of scientific research to which I have referred, this is already the case.

Manufacturing progress has in Germany gone hand in hand with material progress, and any one who has travelled much must be astounded with the extraordinary improvement which has been going on in recent years, not only in German railways, shipbuilding and steel-working, but also in the buildings, order and general amenities of life of the great German cities, such as Berlin, Frankfurt and Cologne. In the competition of manufacture we are pressed very hard from steel to watches, from marine engines to scientific instruments. In nothing, indeed, have German manufacturers made more progress than in the making of all exact instruments. In these departments Germany certainly excels us, so far as original and inventive improvement is concerned.

Now, all this improvement, I feel inclined to attribute, not, with Sir William Harcourt, to any linguistic superiority, but to the far greater opportunities of technical study which are afforded in Germany. If we are to hold our own, we older men must try to multiply these opportunities of study in our own country, and you younger men must do your part by seeking to avail yourselves to the uttermost of any such opportunities provided.

To you, gentlemen, who are about to commence the studies which will be useful to you in your future career, I venture to say a few words. Consider the marvellous progress that has been made in the physical and practical sciences during the century now rapidly drawing to a close. At the commencement of the century steam navigation and railways were unknown and unachieved. Our knowledge of the science of electricity was confined to a few isolated phenomena, and chemistry was in its infancy. Now the latter science has spread its branches until it seems likely it may bring into a common brotherhood the whole of the physical sciences. Consider, further, that knowledge and progress appear to be increasing in a geometric ratio; who then can predict what will be the progress made at the conclusion of the twentieth century, or even during the first half of it? In forwarding that progress I sincerely trust that many of those whom I now address may be prominent workers. We have never wanted in this country the men whom I would call the captains of the scientific army, but I think we are much inferior to Germany in the rank and file, in the number of men who are willing to follow particular lines of investigation, and who thus do invaluable service to science.

We older men, whose careers are approaching their termination, cannot but look with envy on the career which may be open to some of you. It was said of the telescope, which opened to our vision infinite space, that it was balanced by the microscope, which showed us the infinitely small; but small as are these objects, the kinetic theory of gases opens up to our appreciation, I had almost said to our view, molecules whose dimensions are inconceivably smaller. It would be vain to name to you the limiting dimensions of these molecules which have been revealed to us by the labours of Maxwell, Lord Kelvin, Clausius and others, but I have seen somewhere, possibly in the columns of NATURE, a statement which may be more intelligible. It was something like this:—That though the molecules of hydrogen gas are so small that it would take about 50 millions touching one another to make an inch, they are so numerous in a cubic inch of gas at 0° Centigrade and atmospheric pressure, that if the whole of them were formed into a row, they would go round the circumference of the earth more than a thousand times. The molecules also, as you probably know, are in violent motion. The highest velocity I have obtained with a projectile nearly reached 5000 f.s., but the average velocity of the hydrogen molecules at the temperature and pressure I have named is somewhat more. I once calculated that a few molecules, I forget in how many millions, might exceed 50,000 f.s.

We smile, and justly smile, at the seekers after what was

called perpetual motion. Modern science seems to show that it is equally vain to seek for anything that is perpetually and absolutely at rest.

I have alluded to the kinetic theory of gases because we know more of the constitution of that form of matter than we do of any other, but having regard to the progress of science to which I have referred, is it too much to hope that some of you will live to see a second Newton, who will give you a second Principia, which shall clear away the difficulties which surround the constitution of matter whether ponderable or imponderable ?

One word more, bring enthusiasm to your studies ; without it the best instruction (this you will have) and the best apparatus will do nothing for you. Make your work the first aim, and do not let athletics, or anything else, take precedence of it. Here, again, I cannot help thinking that the Germans get a little the better of us. With them work is absolutely in the forefront ; I am not at all sure that it is so with the average young Englishman of to-day. No one appreciates the value of athletics, when kept in their proper place, more keenly than I do. But against the substitution of athletics for the more serious objects of life, I should like to enter my strongest protest, and it will be a sorry day for England if such a change ever takes place.

Lastly, I would say to you, while giving the acquiring of knowledge that may assist your own business or profession the first place, not be too utilitarian, do not narrow the search for knowledge down to a search for utilitarian knowledge, for knowledge that you think will pay. I remember a strong protest of De Morgan's against the number of men who take their station in the business of life without ever having known real mental exertion ; he put it that knowledge which ought to open the mind was decided on solely by its fitness to manure the money tree.

Therefore, above all things, pursue knowledge. It is that pursuit which will stand by you to the end as at once the greatest and the most enduring of pleasures. Friends may die ; the most tender attachments must be severed ; advancing years will very soon debar you from any serious pursuit of athletics ; the acquisition of wealth will take away from you the pleasure of "making a position," which is probably the keenest, and surely the most legitimate, incentive of middle life ; but the pleasure of acquiring knowledge will console you to the last, so long as you have strength to open a book, or to hold a test-tube. Cry after knowledge ; seek for her as silver ; and search for her as for hidden treasure.

## *THE BRITISH ASSOCIATION.*

### SECTION H.

#### ANTHROPOLOGY.

OPENING ADDRESS BY C. H. READ, PRESIDENT OF THE SECTION.

THE difficulties that beset the President of this Section in preparing an address are chiefly such as arise from the great breadth of our subject. It is thought by some, on the one hand, to comprehend every phase of human activity, so that if a communication does not fall within the scope of any other of the Sections into which the British Association is divided, it must of necessity belong to that of anthropology. On the other hand, there are many men, wanting neither in intelligence nor education, who seem incapable of grasping its general extent, but, mistaking a part for the whole, are fully content with the conclusions that naturally result from such a parochial method of reasoning. The Oxford don who stated, a year or two ago, his belief that anthropology rested on a foundation of romance can only have arrived at this opinion by some such inadequate process, and the conclusion necessarily fails to carry conviction. The statement was, however, singularly ill-advised, for anthropology gives way to no other branch of science in its reliance upon facts for its existence and its conclusions. Had the reproach been that the facts were often of a dry and repellent character we might have pleaded extenuating circumstances, but I fear it must have been admitted that there was some justice in the complaint, though we could fairly point to instances where master minds have made even the dry bones of anthropology live, and that without trenching upon the domain of romance.

It is not, however, my purpose to-day to enter upon a general defence of anthropology as a branch of science. It has taken far too firm a hold upon the popular mind to need any such help. I intend rather to treat of one or two special subjects with which I am in daily relation, in order to see whether some practical means cannot be found to bring about a state of things more satisfactory than that at present existing.

The first of these branches is that of the prehistoric antiquities of our own country. It will not be denied that there can be no more legitimate subject of study than the remains of the inhabitants of our islands from the earliest appearance of man up to the time when written history comes to the aid of the archæologist. There is no civilised nation which has not devoted some part of its energies to such studies, and many of them under far less favourable circumstances than ours. The chiefest of our advantages is to be found in the small extent of the area to be explored—an area ridiculously small when compared with that of most of the continental nations, or with the resources at our command for its exploration. The natural attractions of our islands, moreover, have also had a great influence on our continental neighbours, so that their incursions have not been few, and no small number of them decided to remain in a country where the necessaries of life were obtainable under such agreeable conditions. The effect of these incursions, so far as our present subject is concerned, is that there is to be found in the British Islands a greater variety of prehistoric and later remains than is seen in most European countries, a fact which should add considerably to the interest of their exploration. At the same time also it must be borne in mind that it is by such researches alone that we can arrive at any true understanding of the conditions of life, the habits and religious beliefs, or the physical characters of the varied races who inhabited Britain in early times.

It may seem unnecessary to urge, in face of these facts, that all such memorials of the past should be, in the first place, preserved ; and, in the second, that any examination of them should be undertaken only by properly qualified persons. Unfortunately, however, it has never been more necessary than it is at the present time to insist upon both points, and the fact that these prehistoric remains are scattered impartially over the whole country, with the exception, perhaps, of the sites of ancient forests, makes it almost impossible to devise any special measures for their preservation. An additional difficulty is to be found in the fact that many ancient remains, such as the barrows of the early Bronze Age, are altogether unrecognised as such, and in the process of cultivation have been ploughed down almost to the level of the surrounding surface, until at last the plough scatters the bones and other relics unnoted over the field, and one more document is gone that might have served in the task of reconstructing the history of early man in Britain.

Such accidental and casual destruction is, however, probably unavoidable, and, being so, it is scarcely profitable to dwell upon it. We can, perhaps, with more advantage protest against wilful destruction, whether it be wanton mischief or misplaced archæological zeal. An enlightened public opinion is our only protection against the first of these, and will avail against the second also, but we are surely entitled to look for more active measures in preventing the destruction of archæological monuments in the name of archæology itself. It is a far more common occurrence than is generally realised for a tumulus to be opened by persons totally unqualified for the task either by experience or reading. An account may then be printed in the local journal or newspaper. When such accounts do appear it is often painfully obvious that an accidental and later burial has been mistaken for the principal interment, while the latter has been altogether overlooked, and no useful record has been kept of the relative positions of the various objects found. The loss that science has suffered by this indiscriminate and ill-judged exploration is difficult to estimate, for it should be borne in mind that an ancient burial, once explored, is destroyed for future searchers—no second examination can produce results of any value, though individual objects overlooked by chance may repay the energy of the later comers. So much varied knowledge is, in fact, required for the proper elucidation of the ordinary contents of a British barrow that it is almost impossible for any single person to perform the task unaided. A wide experience in physical anthropology must be combined with an acquaintance fully as wide with the ordinary conditions of such interments and the nature, material, and relative positions of the accompanying relics, all of which must be brought to bear, with discriminating judgment, on the facts laid bare by the digger's spade. Added to this, the greatest precaution is needed that nothing of value be overlooked. In

some soils, such as a stiff clay, it is almost impossible to guard against such a casualty, especially when the barrow is of large size and vast masses of earth have to be moved. The amount of profitable care that may be bestowed on scientific work of this character can nowhere be better seen, I am glad to say, than in our own country, in the handsome volumes produced by General Pitt-Rivers as a record of his investigations in the history of the early inhabitants of Dorsetshire. The memoirs contained in them are unsurpassed for scientific thoroughness, and they will probably long stand as the model of what archæological investigation should be. It is very seldom, however, that circumstances conspire so favourably towards a desired end as in the case of General Pitt-Rivers, where a scientific training is joined to the love of research, and finally ample means give full scope for its practice under entirely favourable conditions. While it is, perhaps, too much to expect that all explorations of this character should be carried through with the same minute attention to detail that characterises General Pitt-Rivers's diggings, yet his memoirs should be thoroughly studied before any work of the same kind is entered upon, and should be kept before the mind as the ideal to be attained. It is not too much to say that a diligent study of the works of the two foremost explorers of prehistoric remains in this country—Canon Greenwell and General Pitt-Rivers—will of itself suffice to qualify any intelligent antiquary to conduct the exploration of any like remains. At the same time, it must not be forgotten that exploration is one thing and a useful record of it is another, and here the explorer would do well to invite the co-operation of specialists if he would get the full value out of his work, and there is generally little difficulty in getting such help.

I have ventured to point out, in moderate terms, the dangers to which a large number of our prehistoric sites are liable, and to state under what conditions they should be investigated. It is not unreasonable to expect, if the danger is so obvious, that a remedy should be forthcoming to meet it. In most of the continental States it would be easy to institute a scheme of State control by which such sites would vest in the Government to just such an extent as would be necessary to prevent their being destroyed, and such a scheme might be cheerfully accepted and applied with success in any country but our own. Here, however, we are so accustomed to rely upon individual influence and exertion in matters of this kind, that an appeal to the Government is scarcely thought of; while, on the other hand, the rights of property are fortunately so safeguarded by our tradition and law that nothing but a futile Act of Parliament would have the least chance of passing. Moreover, experience teaches us that it is not to State control that we must look. The Ancient Monuments Bill, which was intended to protect a special class of monuments, and was framed with a full regard to the rights of owners, still stands in the Statute Book, but for years past it has had no effective value whatever. That being so, we must look to private organisations, and preferably to those already in existence, for some effectual moral influence and control, and, in my judgment, the appeal could best be made to the local scientific societies. Many of these are very active in their operations, and could well bear an addition to their labours; others, less active, might become more energetic if they had a definite programme. The plan I would propose is this:—Each society should record on the large scale Ordnance map every tumulus or earthwork within the county, and at the same time keep a register of the sites with numbers referring to the map, and in this register should be noted the names of the owner and tenant of the property, as well as any details which would be of use in exploring the tumuli. I am well aware that a survey of this kind has been begun by the Society of Antiquaries of London, and is still in progress; but this is of a far more comprehensive character, and is, moreover, primarily intended for publication. The more limited survey I now advocate would in no way interfere with it, but, on the contrary, would provide material for the other larger scheme. Once the local society is in possession of the necessary information just referred to, it would be the duty of its executive to exercise a beneficent control over any operations affecting the tumuli, and it may safely be said that such control could in no way be brought to bear so easily and effectively as through a local society.

Some of the arguments in favour of some such protection for our unconsidered ancient monuments have been already briefly stated, and, in conclusion, I would only urge this in their favour, that while the more beautiful monuments of later and historic times are but little likely to want defenders, the less attractive early remains are apt to disappear not so much from want of appreciation as from want of knowledge, and I would repeat that it is from them alone that we can reconstitute the life-story of those who lived in what we may, with truth, call our dark ages.

I will now ask you to turn your attention to another matter in which it seems to me that this country has opportunities of an unusually favourable kind. I refer to the collection of anthropological material from races which still remain in a fairly primitive state. It is somewhat trite to allude to the extent of our Empire and the vast number of races either subject to our rule or who look to us for guidance and protection. The number may be variously computed according to the bias, philological or physical, of the observer, but it will not be contested that our opportunities are without precedent in history, nor that they greatly exceed those of any existing nation. That being so, it may not be useless to see how far these opportunities are utilised. While it will not be denied that the Indian Government and the Governments of some of our Colonies have done excellent work in the direction of anthropological research and publication, and that exhaustive reports from our Colonial officials are frequently received and afterwards entombed in parliamentary papers, yet it is equally clear that work of this kind is not a part of our administrative system, but rather the protest of the intelligent official mind against the monotony of routine. The material, the opportunity, as well as the intelligence and will to use both, are already in existence, and all that is now wanted is that the last should be encouraged, and the work be done on a systematic plan, and, as far as may be, focussed on some centre where it may be available for present and future use. It was for this end that I ventured to bring before the British Association at the Liverpool meeting a scheme for the establishment of a central Bureau of Ethnology for Greater Britain. Frequent appeals had been made to me by officials of all kinds in distant parts of the Empire to tell them what kind of research work they could most usefully undertake, and it seemed a pity not to reduce so much energy and good will into a system. Hence the Bureau of Ethnology. The Council of the Association, on the recommendation of the Committee, invited the Trustees of the British Museum to undertake the working of the Bureau; this they have accepted, with the result that if the Treasury will grant the small yearly outlay it will be under my own supervision. If I had foreseen this ending I might have hesitated before starting a hare the chasing of which will be no sinecure.

It was considered necessary, before attempting to begin the work of the Bureau by communicating with commissioners and other officials in the various Colonies and Protectorates, to lay the matter before Lord Salisbury and to invite his approval of the scheme. The whole correspondence will appear in the Report of the present meeting, but I may be pardoned for quoting one paragraph of the circular letter from the Foreign Office to the several African Protectorates. It is as follows: "Lord Salisbury is of opinion that Her Majesty's officers should be encouraged to furnish any information desired by the Bureau, so far as their duties will allow of their doing so, and I am to request you to inform the officers under your administration accordingly." When it is remembered that this is strictly official phraseology, its tenor may be considered entirely satisfactory, and there can be little doubt that other departments of the Government will recognise the utility of the Bureau in the same liberal spirit. Thus we shall have within a short time an organisation which will systematically gather the records of the many races which are either disappearing before the advancing white man, or, what is equally fatal from the anthropological point of view, are rapidly adopting the white man's habits and forgetting their own.

The Bureau of Ethnology, however, will only perform a part of the task that has to be done. While there is no doubt of the value of knowledge as to the religious beliefs and customs of existing savages, it is surely of equal importance that anthropological and ethnological collections should be gathered together with the same energy. The spear of the savage is, in fact, far more likely to be replaced by the rifle than is his religion to give way to ours. Thus the spear will disappear long before the religion is forgotten. It may be said that we have collections of this kind in plenty, and it is true that in the British Museum, at Oxford, Cambridge, Liverpool, and Salisbury, there are indeed

excellent collections of ethnology, while at the College of Surgeons and the Natural History Museum there are illustrations of physical anthropology in great quantity. Whatever might be the result if all these were brought together, there can be no question that no one of them meets the requirements of the time. Here also there is a want of a system that shall at once be worthy of our Empire and so devised as to serve the ends of the student. Where, if not in England, should be found the completest collections of all the races of the Empire? It must be admitted, however, not only that we have no national collection of the kind, but that other nations are ahead of us in this matter. This could be readily understood if their sources of supply were at all comparable to ours. But this is, of course, very far from being the case. The sources are ours in great part, and if we stand inactive it is not unlikely that some will be exhausted when we do come to draw upon them. It is, perhaps, better to give here a case in point rather than to rely on general statements. In the summer of last year I arranged, with the approval of the Trustees, that Mr. Dalton, one of the officers of my department, should make a tour of inspection of the ethnographical museums of Germany, with a definite object in view, but at the same time that he should make a general survey of their system and resources as compared with our own. The report which he drew up on his return was printed and has recently been communicated to the newspapers; it is therefore not necessary to allude to it now, except to quote one instance confirming my statement that it is to a great extent from our Colonies that material is being drawn. Mr. Dalton says: "On a moderate estimate the Berlin collections are six or seven times as extensive as ours. To mention a single point, the British province of Assam is represented in Berlin by a whole room and in London by a single case." But even this, forcible though it is, does not adequately represent the vast difference between the material at the disposal of the two countries. For it is the habit of the collectors for the German museums to procure duplicates or triplicates of every object, for the purposes of exchange or study. It is thus not unlikely that the whole room referred to represents only a part of the Berlin collection from the British province of Assam. In making these observations, I should be sorry if it were thought that I wish to advocate a dog-in-the-manger policy, or that I consider it either desirable or politic to place any restriction upon scientific work in our Colonial possessions, even if such restrictions were possible. I would prefer to look at the matter from an entirely different point of view. If the German people, who are admittedly practical and business-like, think it worth while, with their limited Colonies, to spend so much time and money on the establishment of a royal museum of ethnography, how much more is it our duty to establish and maintain one, and on a scale that shall bear some relation to the magnitude of our Empire. The value of such museums is by no means confined to the scientific inquirer, but they may equally be made to serve the purpose of the trader and the public at large.

How can we best obtain such a museum? That is the question that we have to answer. It is scarcely profitable to expect that the Government will be stirred to emulation by the description of the size and resources of the Museum für Völkerkunde in Berlin. In the British Museum there is at the present time only the most limited accommodation even for the collections already housed there, and I am well aware that these form a very inadequate representation of the subject.

It may be thought that the solution of this difficulty is easy. It is well known that the Government has purchased the rest of the block of land on which the British Museum stands, and it may seem that such a liberal extension as this will form should be enough for, at any rate, a generation or two, and that a little additional building would meet immediate wants, and enable the collections, now so painfully crowded, to be set out in an instructive and interesting way. I admit that if the whole of the contemplated buildings were at this moment complete, and at least double as much space given to the ethnographical collections as they occupy at present, the difficulty would be much simplified. The collections could at any rate be then displayed far more worthily and usefully. Even this, however, would hardly meet the case, even if there were a certainty of the buildings being immediately begun. Such works as these, however, can only be executed in sections during the course of each financial year. Thus, even if a Chancellor of the Exchequer could be found to fall in entirely with the views of the Trustees, it would still be an appreciable number of years before the completion of the entire range of galleries that is contemplated. For this reason alone I do not look forward to obtaining the space that is even now urgently wanted for some time. Meanwhile the natural and legitimate increase of the collections at the rate of about 1 to 2 per cent. per annum still goes on, and the original difficulty of want of room would still face us, though in a lesser degree. This estimate of the rate of increase may seem a high one; but it should not be forgotten that the science is new, and that it is only within the last few years that such collections have been made on scientific lines, instead of being governed only by the attractive character or rarity of the object. The gaps that exist in such a series as that of the British Museum, made in great part on the old lines, are relatively more numerous than would be the case in museums more recently founded. Another reason, equally cogent, for allowing far more room than is required for the mere exhibition of the objects is that, in my judgment, ethnographical collections, to be of real value, need elucidation by means of models, maps and explanatory descriptions, to a far greater extent than do works of art, which to the trained eye speak eloquently for themselves. Such helps to understanding necessitate a considerable amount of space, though the outlay is fully justified by their obvious utility, and in any general scheme of rearrangement of the national collection they should be considered an essential feature.

There is yet another factor to be considered. It has been the fashion in this country to consider remains illustrating the physical characters of man to belong to natural history, while the productions of primitive and uncultured races generally find a place on the antiquarian side. Thus the skull of a Maori will be found at the natural history branch of the British Museum, while all the productions of the Maori are three miles distant in Bloomsbury. Such an arrangement can perhaps be defended on logical grounds, but its practical working leaves much to desire, and the arguments for a fusion of the two are undoubtedly strong. For instance, the student of one branch would be unlikely to study it alone without acquiring a knowledge of the other, while the explorers to whom we look for collections usually give their attention to both classes of anthropological material. Here again, in such a case, there would be a call for still more space at Bloomsbury.

If I may be permitted to add one more to the requirements of what should be an attainable ideal, I should like to say that courses of lectures on anthropology delivered in the same building that contains the collections would form a fitting crown to such a scheme for a really Imperial museum of anthropology as I have endeavoured to sketch. There is but one chair of anthropology in this country, and admirably as that is filled by Prof. Tylor, he would himself be the first to admit that there is ample room and ample material to justify the creation of a second professorship.

It will be admitted that if my premisses are well founded the conclusion must necessarily be that we cannot look to the British Museum to furnish us eventually with the needful area and other resources for the installation of a worthy museum of anthropology. The difficulties are far too great for the Trustees to overcome, unless by the aid of such an exhibition of popular enthusiasm as I fear our branch of science cannot at present command. Failing the British Museum, which may be called the natural home of such a collection, we must look elsewhere for the necessary conditions, and I think they are to be found, although it is possible that, however favourable these conditions may seem from our point of view, difficulties may already exist or arise later.

It is not the first time that a scheme has been thought out for the establishment of a museum or kindred institution which should represent our Colonies and India. In the year 1877 the Royal Colonial Institute made a vigorous effort in this direction, and, in combination with the various chambers of commerce throughout the country, advocated the building of an "Imperial Museum for the Colonies and India" on the Thames Embankment, with the then existing India Museum as a nucleus. The arguments then brought forward were in the main commercial, but they are, if anything, more forcible now than they were twenty years ago. The competition with foreign countries has become keener on the one hand, while the bonds between the Colonies and the parent country are notoriously closer and more firm than at any previous time. No moment could thus be more opportune than the present for the foundation of a really Imperial Institution to represent our vast Colonial Empire.

The last sentence has, perhaps, given an indication of my solution of the question. The Imperial Institute at South Kensington has now been in existence for some time, and has passed through various phases. But its most enthusiastic supporters will scarcely claim for it entire success in its mission. Whatever may be the underlying causes, it must be admitted that such popular support as it possesses is scarcely founded on the performance of its functions as an Imperial Institute. It would seem, therefore, that something more is wanted—a more definite *raison d'être*—than it has at present, and this I think it will find in being converted into such a museum of anthropology as I have indicated, but, of course, as a Government institution. I am by no means an advocate of the creation of new institutions, if the old ones can adequately do their work, nor do I think that anything but ill would result from a general partition of the contents of the British Museum. The separation of the natural history from the other collections was painful, though inevitable, and no such severe operation can be performed without loss in some direction. But the removal of the ethnographical and anthropological collections from the British Museum to the galleries of the Imperial Institute would possess so many manifest advantages that the disadvantages need scarcely be considered. The Government has already taken over a portion of the building for the benefit of the University of London. The remaining portion would provide ample accommodation for the anthropological museum, as well as for the commercial side, that might properly and usefully be continued; its proximity to the natural history branch of the British Museum would render control by the Trustees easy; the Indian collections, which formed so important a feature in the scheme of 1877, are at this moment under the same roof; and finally the University of London has but to found a chair of anthropology, and the whole of the necessary conditions of success are fulfilled.

I have but little doubt that, wherever it might be placed, the creation of a distinct department of anthropology would of itself tend to the enrichment of the collections. It must be remembered that it is only since 1883, when the Christy collection was removed to the British Museum, that the ethnographical collections there can claim any kind of completeness. Until then one small room contained the few important objects of this kind that had survived from the voyages of Cook, Wallis and the other early voyagers. The public did not expect to find ethnography in the British Museum, and it is, in fact, only within the last few years that it has been generally realised that a gallery of ethnography exists there. If it were placed in such a building as the Imperial Institute, it would still remain part of the British Museum, and be under the guardianship of its Trustees; but it would obviously command more attention and support from the public than can be expected while it remains an integral part of a large institution which has as many aims as it has departments.

I began this address by stating that it would have a practical application. I trust that to others it may seem that what I have ventured to suggest is not only possible of achievement, but would also be beneficial to the branch of science that we represent. I should like to add that, as far as possible, I have tried to state the case as it would appear to one who regarded the situation from an entirely independent standpoint, and wishing only to discover the most practical solution of what must be admitted to be a difficult question. My allegiance to the British Museum, however, may well have tinged my views, unnoticed by myself. There are many other subjects that might well have formed the subject of an address at the present time. On such occasions as these, however, it is, I think, advisable to select a subject with especial reference to the needs of the time, and I know of nothing that is at the present moment more urgent in this particular direction, and in my judgment it will tend greatly towards the true advancement of science, the object we all have at heart.

## SECTION I.

### PHYSIOLOGY.

### Opening Address by J. N. Langley, F.R.S., President of the Section.

One might suppose that physiology, dealing as it does for the most part with structures—such as nerves, and muscles, and glands—which every one has and has heard of, would be eminently a science the newer aspects of which every one could readily understand. And in this supposition one would be encouraged by the frequency of the references in English literature to some part of our inner mechanism. More than a century and a quarter ago we find: "If 'tis wrote against anything, 'tis wrote an' please your worships against the spleen, in order by a more frequent and more convulsive elevation and depression of the diaphragm, and the succussations of the intercostal and abdominal muscles in laughter, to drive the gall and other bitter juices from the gall-bladder, liver and sweetbread of his Majesty's subjects, with all the inimicitious passions which belong to them, down into their duodenums."

It must, however, be recognised that many subjects which are most interesting to the physiologist either involve so much special knowledge, or are so beset with technical terms, that it is difficult to make clear to others even their general drift.

I am not without uneasiness that my subject to-day may be found to fall within this category. I propose to consider some relations of the nerves which pass from the brain and spinal cord, and convey impulses to the other tissues of the body—the motor or efferent nerves; and in especial the relations of those efferent nerves which run to the tissues over which we have little or no voluntary control. It is as well to say at once that none of the general conclusions which I lay before you are encrusted with universal acceptance. One or two have been subjects of controversy for the last fifty years; others are too young to have met even with contradiction. I do not propose to give you an account of the various theories which have been put forward on the questions I touch upon, nor do I propose to point out how far the views I advocate are due to others. I am concerned only to state what seems to me to be the most probable view with regard to certain problems which have been emerging from obscurity in recent year.

*Limitations in the Control of the Nervous System over the Tissues of the Body.*—In view of the conspicuous manner in which nervous impulses affect every-day life, we are perhaps apt to over-estimate the character and range of the influence exercised directly by the nervous system.

From the early part of this century one way of regarding the body has been to consider it as made up of tissues grouped together in varying number and amount. Each tissue has its characteristic features under the microscope. We need not enter into the question as to which of the commonly recognised tissues of the body are to be regarded as forming a class by themselves and which are to be regarded as subdivisions of a class. The point I wish to lay stress on is that in any broad classification not more than two tissues are known to be supplied with approximate completeness with efferent nerve-fibres. The striated muscular tissue, which forms, amongst other parts of the body, the muscles of the limbs and trunk, receives in all regions nerve-fibres from the brain or spinal cord. And the unstriated muscular tissue, which forms, amongst other parts of the body, the contractile part of the alimentary canal and of the blood-vessels, is in nearly, and possibly in all, regions similarly supplied.

The glandular division of epithelial tissue in some parts responds promptly and strikingly to nervous impulses, but in some parts the response is feeble, and in others no nervous impulse has been shown to reach the tissue. The connective tissue which exists all over the body, and which in its varied forms of connective tissue proper—cartilage, bone, teeth, epithelioid cells—makes so considerable part of it, is in mammals, so far as we know, destitute of efferent nerve-fibres. The epidermic cells, which form a covering for the body, the ciliated cells, the reproductive cells, do not visibly respond to any nerve stimulus. And the myriads of blood corpuscles, which in different ways are in incessant action for the general welfare, are naturally out of range of nervous impulses. According to our present state of knowledge, large portions of the organism live their own lives uninfluenced, except indirectly, by the storms and stresses of the central nervous system. No nervous impulse can pass to them to make them contract or to make them secrete, or to quicken or slacken their inherent activity. The nervous system can only influence them through the medium of some other tissue by changing the quantity or quality of the surrounding fluid.

Regarding, then, the body from the point of view of the control exercised by the nervous system on the other constituents, we have first to recognise that this control is in considerable part indirect only, that the several tissues are in varying degree under direct control, and that different parts of

one tissue may be influenced by the nervous system to different extents.

*Limitation in the Control of the Nervous System over the different Activities of the Cell.*—Even when nervous impulses can strikingly affect the vital activity of a tissue, their action is limited. They cannot modify the activity in all the various ways in which it is modified by the inherent nature of the tissue and the character of the surrounding fluid. Thus the submaxillary gland which pours saliva into the mouth is in life ceaselessly taking in oxygen and giving out carbonic acid; it does this without pouring forth any secretion. So far as we know, no nervous impulse can hasten or retard this customary life of the gland by a direct action upon it without producing other changes. The nervous system can only do this indirectly by modifying the blood supply. The nervous impulse which reaches the gland cells causes them to secrete, to take up fluid on one side and to pour it out on the other, and it does not, and so far as we know it cannot, confine its influence to those changes ordinarily going on in the gland cells. The essential effect of a nerve impulse appears to be to modify the amount of energy set free as work; usually it causes work to be done, as in the contraction of a muscle, or in the secretion of fluid by a gland; sometimes it diminishes the work done, as in the cessation of a heart-beat, or the decrease of contraction of a blood-vessel. Other changes often go on side by side with this setting free of energy as work, but there is no unimpeachable instance in which these other changes take place by themselves as the result of nervous excitation. Physiologists have sought for long years in all parts of the body for nerves—calorific or frigorific nerves—which cause simply an increase or decrease of the heat set free by a tissue; and for nerves—trophic nerves—which cause simply chemical changes in the tissue associated with a setting free of heat or not. Probable as the existence of such nerves seems to be, the search for them cannot, I think, be said to have been successful.

*Somatic or Voluntary Tissues.*—When we look at the question of nervous control subjectively, and consider in ourselves what tissues are at our beck and call, we find that we have immediate and prompt governance over one tissue only, the one which, as we have already seen, is most universally supplied with efferent nerve-fibres—namely, the (fibrous) striated muscular tissue. The parts of the body composed of this muscular tissue we move, as we say, at will. We exercise a control over it that we cannot exercise over any other tissue. The tissue is supplied with a special system of nerves. In other vertebrates there is a tissue of similar microscopical characters, and having a similar system of nerves. And we can be certain that in all vertebrates the fibrous striated muscle and the nervous system belonging to it form a definite portion of the body which can be properly placed in a class apart from the other tissues of the body. The tissues in this class are spoken of as "somatic" tissues, or sometimes, in view of our own sensations, as "voluntary." "Voluntary" is not a word which physiologists care much to use in this context, because it readily gives rise to misconceptions. It will serve, however, if we bear in mind that the primary distinguishing characters of the system are microscopical, anatomical and developmental; that other tissues than "voluntary" can be put in action by the will, though in a different fashion; and that "voluntary" tissues are also put in action involuntarily. That is to say, the word will serve if we rob it of much of its ordinary meaning.

The somatic or voluntary nervous system has in its essential features long been known. We may leave it and pass on to a more obscure field.

*Autonomic or Involuntary Tissues.*—In putting on one side the voluntary system, you will notice that we have disposed of one only of the several tissues, differing microscopically from one another, which go to make up the various organs of the body. Of the rest some, as we have said, either do not receive nerve-fibres from the brain and spinal cord, or, if they do, practically nothing is known about them in our own class of vertebrates—the mammalia. These I shall say a word or two about later. For the present we must confine our attention to the tissues which are known to be supplied not too illiberally with nerve-fibres. These are unstriated muscle, and its allied cardiac muscle, and certain glands. Since the voluntary striated muscle has a nervous system of its own, it might be imagined that the unstriated tissue and the glandular tissue, differing as they do, would also have separate nervous systems. This, however, is not the case. The nervous supply of these two tissues have common features and belong to the same system. There is, unfortunately, no satisfactory term by which to designate it. On the whole the term "autonomic" seems to me best adapted for scientific use. But it is not of the first importance for our present purpose to insist upon a proper nomenclature, so that I think I shall not do much harm if I use the familiar "involuntary" for the unknown, or nearly unknown, "autonomic."

I need hardly point out how widespread are both the glandular and the unstriated muscular tissues. In man practically the whole surface of the skin is supplied with sweat-glands, lachrymal glands lie hid behind the eye, small glands are thick in the respiratory tract from the nose to the smaller bronchial tubes, and glands stretch along the whole of the digestive tract. Most of these can be set in action by nerve-fibres. There are a number of others in which such action has not been shown, so that they do not concern us at present. Unstriated muscle forming, as it does, part of the walls of the arteries and veins, penetrates to every part of the body. It forms a large part of the coats of the stomach and intestines; it is present in the spleen and in parts of the lymphatic vessels; it is present in the iris and in other parts of the eye; it occurs in greater or less amount in different animals in the deeper layers of the skin.

Consider some of the ways in which these tissues in the several organs or structures affect the working of the body. The heart contracts and supplies the driving force for the circulation of the blood; the arteries contract less or more, here or there, and regulate the amount of the blood to each region; the digestive tract secretes solvent and disintegrating fluids in the food, churns it into pulp, absorbs some and rejects the rest; the skin-glands pour out their tiny beads of perspiration, and so aid in regulating the temperature of the body; the iris commands the aperture of the pupil and determines the amount of light falling on the retina; the ciliary muscle, by its varying contraction, brings about the focussing necessary for distinct vision.

But the involuntary tissues do not confine themselves to actions of such flagrant utility as those just mentioned. The contraction of small bundles of unstriated muscles in the skin will cause the flesh to creep; other similar small muscles are attached to the hairs; 'tis these will make

> "Thy knotted and combinèd locks to part,
> And each particular hair to stand on end,
> Like quills upon the fretful porpentine."

The involuntary tissues, although not under the prompt and immediate control of the will, are under the control of the higher centres of the brain. They are particularly responsive to the emotions; and in so far as we can call up emotions, we can play upon them at will. The ease with which nervous impulses pass along given tracts depends, amongst other things, upon use. And so it appears that our great-grandfathers wept and our great-grandmothers fainted with an ease which we should require assiduous practice to attain.

Further, you may note that the contraction of involuntary muscle caused by an emotion may in its turn set up nervous impulses, which pass back to the brain and give rise to vague and curious feelings, feelings often lending themselves to effective literary expression:—

> "Where our heart does but relent, his melts; where our eye pities, his bowells *yearn*."

I must ask your forgiveness for mentioning so many well-known facts in the sketch which I have just given of the involuntary tissues. But I hope it will take from you all excuse for not understanding the rest of what I have to say.

*The arrangement of the involuntary nervous system* presents some peculiar characters. The most distinctive of these is that the nerves, after they leave the brain or spinal cord, do not run interruptedly to the periphery; they end in nerve-cells, and the nerve-cells send off the fibres which run to the periphery. The most direct proof of this lies in the fact that a certain amount of nicotine prevents the central nervous system from having any influence on the peripheral structures—*i.e.* the line is somewhere blocked; it can be shown, speaking generally, that there is no block on either side of the ganglia, so that it must be in them. The actual point of attack of the nicotine appears to be the connections made by the central nerve-fibres with the peripheral nerve-cells. Thus all nerve-impulses, which pass from the brain or spinal cord to unstriated muscle or glandular tissue, pass through an intermediate station on their way. In

this, as in some other respects, the arrangement of the involuntary nervous system is more complex than that of the voluntary nervous system; in the latter the motor nerve-fibres run direct to the tissue and have no nerve-cells on their course. The nerve-cells which form the intermediate stations for the involuntary nerve-fibres are grouped together into ganglia; and so we may call the nerve-fibres which run from the brain or spinal cord to the nerve-cells pre-ganglionic fibres, and the nerve-fibres which run from the ganglia to the peripheral tissues post-ganglionic nerve-fibres.

The involuntary nervous system is divided into at least two subdivisions. The most extensive of these is what is called the *sympathetic nervous system.* The pre-ganglionic fibres of the sympathetic arise from a limited portion of the spinal cord. They arise from that part of the spinal cord which is in the region of the chest and the small of the back—*i.e.* roughly from the part which lies between the origin of the voluntary nerves for the arms and the origin of the voluntary nerves for the legs. The fibres given off by the ganglia of this system—*i.e.* the post-ganglionic fibres—run to the involuntary tissue in all parts of the body.

*The Cranial and Sacral Systems.*—The second division of the involuntary nervous system consists of two parts: one part—the cranial—arises from the brain—*i.e.* above the origin of the sympathetic; the other—the sacral—arises from the end of the spinal cord—*i.e.* below the origin of the sympathetic.

Each supplies a limited and different part of the involuntary tissue of the body, but both together supply a portion only of it. Taking the distribution broadly, they supply the muscular coats of the alimentary canal and certain structures connected developmentally with the anterior and posterior portions of it. They are especially connected with these terminal portions; they send numerous nerve-fibres to them; whereas they send but few to the intervening portion, and none at all to its blood-vessels. Thus parts of the involuntary tissue of the body receive a double supply of nerve-fibres, whilst parts receive a single supply only. Amongst the latter are all the involuntary tissues of the skin, the blood-vessels of the limbs and trunk, and of most of the viscera.

The cranial and sacral divisions of the involuntary nervous system are considered by some observers to be simply portions of the sympathetic system separated from it by the development of the nerve-centres for the arms and for the legs. I may give one reason why I do not take this view. The middle portion of the spinal cord, which is the region that sends fibres to the sympathetic, always sends fibres to a given spot by more than one nerve, and usually by four or five. The fibres passing by the several spinal nerves never differ in the kind of effect they produce, but only in the degree of effect; the difference is in quantity and never in quality. If, then, regions above and below were mere separated parts of this sympathetic region, we should expect that when one of these regions and the sympathetic region sent nerves to the same spot, the effect produced by both sets of nerves would be the same in kind, though it might differ in extent. But this is often not the case. Thus certain blood-vessels may receive nerve-fibres from four spinal nerves in the sympathetic region and from three spinal nerves in the sacral region; all the former cause contraction of the blood-vessels, all the latter cause dilation. And thus it seems to me probable that in the evolution of mammals the sympathetic nerves have developed at one time, and the cranial and sacral involuntary nerves have developed at another time.

*Inhibition.*—A striking feature of the involuntary nervous system is its possession of nerve-fibres which, when excited, stop some action at the time going on. The most striking example is perhaps the cessation of the heart-beats brought about by excitation of the vagus nerve. Such nerve-fibres are called inhibitory nerve-fibres, and the stopping of the action is called inhibition.

So far as has been definitely proved inhibitory nerve-fibres only run to involuntary muscle and to nerve-cells, and to these, so far as has been certainly shown, only in particular cases. It is true that when fear or other emotion causes the tongue to cleave to the roof of the mouth, there is a cessation of the customary flow from certain glands, but this flow is itself the result of nervous impulses passing in ever rising and falling intensity from the central nerve-cells, and its cessation is due to inhibition of nerve-cells, and not to inhibition of glandular cells.

The inhibition of nerve-cells has only been proved to take place in the central nervous system. When a group of nerve-cells of the central nervous system is engaged in sending out nervous impulses, other nervous impulses reaching them by way of other nerve-cells may diminish or stop their activity. The theory which is commonly advocated now to explain this inhibition makes the activity of the nerve-cells depend upon their receiving stimuli from the minute endings of other nerve-cells, and the cessation of the activity to depend upon these minute endings, either withdrawing themselves out of range, or having something interposed between them and the nerve-cells, so that the impulses can no longer pass. This theory I do not wish to discuss to-day; it is sufficient to say that if it is true, the inhibition of nerve-cells is an entirely different process from that of the inhibition of involuntary muscle.

Turning to the inhibition of involuntary muscle, there is a source of confusion which we must first guard against. Nearly all the unstriated muscle in the body is kept in a state of greater or less tone, or contraction, by the central nervous system. A diminution or cessation of this contraction may then be caused by a diminution or cessation of the activity of the central nervous system. This cessation of contraction is, of course, not what we mean by an inhibition of the unstriated muscle. It is usually spoken of as an inhibition of the nervous centre. The inhibition we mean is that which is caused by stimulating the peripheral end of a nerve outside the spinal cord.

I have said that this inhibition can only be obtained in certain cases, and it is not easy to find anything in common with regard to these cases. But on the whole it appears that the more a tissue is able to work by itself, the more likely it is to be under the control of inhibitory fibres. The heart, stomach and the intestines work when no longer connected with the central nervous system, and these are especially liable to inhibition.

There has been a marked tendency amongst physiologists, in considering the question of inhibitory nerve-fibres, to take what may be called *the view of the equal endowment of the tissues.* Because some arteries have inhibitory nerve-fibres, therefore it is to be held as in the highest degree probable that all have. And many would go further and say that it is therefore in the highest degree probable that all unstriated muscle, and glands, and even the voluntary muscles, have such fibres. This view seems to me a mistaken one. There is hardly room for doubt that the motor fibres are supplied in most unequal measure to the unstriated muscle and glands of the body. There are veins in the body containing unstriated muscle, which show no visible contraction from any nerve stimulation. And there are a number of glands which no nerve—so far as we know—excites to secretion. Since in the course of the evolution of the organism, a universal development of motor fibres has not occurred, it is, I think, to be expected that the development of inhibitory fibres should be still less universal. For up to a certain point the results of inhibition can be obtained in most cases without inhibitory nerve-fibres, by a simple diminution in the impulses travelling down the motor fibres. The only, and the final, test is of course experiment. But not all experiments are decisive, and theory inevitably colours interpretation. This theory of the equal endowment of the tissues has, it seems to me, caused a number of quite inconclusive experiments to be accepted as offering satisfactory evidence for the existence of inhibitory nerve-fibres.

Passing from this question, we may consider briefly how far we can get on the way to understand what occurs during inhibition. The external characteristic feature of inhibition is that a certain state of activity ceases; a muscle contracting at short intervals ceases to contract, or a muscle in a steady state of contraction loses this state. The tissue in either case becomes flabby.

The activity of a tissue may obviously be due to its receiving some stimuli from the nervous system or to its own inherent qualities. In the former case, if the tissue were only active when receiving nervous impulses, we should naturally look to some interference with these impulses as being the cause of inhibition. The blood-vessels of the sub-maxillary gland appear to me to offer sufficiently clear evidence with regard to the inhibition of blood-vessels. The superior cervical ganglion is the local centre from which the nerve-fibres bringing about contraction run to the blood-vessels of the gland. When this ganglion has been removed and the nerve-fibres from it have degenerated, the vessels receive no nervous impulses causing them to contract. But stimulation of the inhibitory nerve will still cause dilation—*i.e.* inhibition of the blood-vessels. The

inhibition must then be due to a direct action on the tissue, and not to an interference with other nerve-impulses. The evidence with regard to the inhibition of the beat of the heart and of the tone or peristalsis of the alimentary canal is more complex, but there is good reason to believe that the contraction is in both cases due to their inherent qualities. And if this be granted, it follows that here also inhibition must be due to a direct action upon the tissue.

The contraction of a muscle is due to a chemical change in it. In this chemical change some energy is set free as work—shown by the contraction of the muscle—and some as heat. It is conceivable that the nervous stimulus which causes inhibition should cause all the energy set free by the chemical change to take the form of heat. In that case the inhibitory nerve would be a calorific nerve. The amount of chemical change is indicated by the amount of carbonic acid given off to the blood. No experiments have been made as to the amount of carbonic acid given off to the blood by an inhibited tissue, but it appears very unlikely that the amount is increased, and we may take this view of the action of an inhibitory nerve as improbable.

If the nervous impulse does not act in this way it must in some way stop the particular chemical change associated with contraction from taking place. It does not stop all chemical change, for blood passing through an inhibited tissue loses some of its oxygen. The simplest way for a nervous impulse to prevent a particular chemical change is to induce a different one. We have seen that the tissues which are inhibited have a great tendency to contract of themselves—that is, they form certain very unstable substances. In closely related tissues which are not inhibited this tendency exists but little or not at all. The

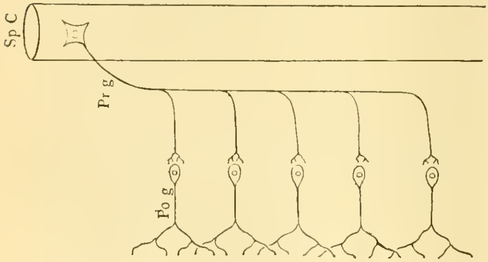



FIG. 1.

proximate cause of inhibition might then be that the nervous stimulus causes certain molecules of the tissue to form more stable combinations. This need not be associated with any general assimilation; it would simply make the muscle adopt for a time a mode of life more like that of other closely related muscle.

*Number of Relay Stations.*—I have already mentioned that the nerve-fibres which pass from the central nervous system to the involuntary tissues do not run to it direct, but end in groups of nerve-cells or ganglia from which fresh nerve-fibres are given off. Now, in most cases, there are anatomically several ganglia on a nerve in its course from the spinal cord to the periphery. For example, the nerve-fibres which cause the hairs of a cat's tail to stand on end, giving the tail the appearance of a bottle brush, leave the spinal cord in the lower part of the back, and enter a nerve-strand which is beaded with ganglia. They leave this strand near the root of the tail. Between the point where the nerve-fibres enter and the point where they leave the strand there are seven or eight ganglia. The fact offers us a problem of some difficulty. With how many of these ganglia are the nerve-fibres connected? Or, in other words, how many relay stations are there—eight or one, or some intermediate number? Further, do all kinds of involuntary nerve-fibres in all parts of the body have the same number of relay stations, or do some have one, some two, some three, and so on? It would take too long to discuss this question here. But the experimental evidence is, I think, fairly decisive in favour of the simple view that the nerve-impulse passes through one relay station only. There is, however, evidence that the nerve-fibres which pass from the spinal cord branch, so that we may take the element by reduplication of which the involuntary nervous system is built up to be diagrammatically as in Fig. 1.

*Reflexes.*—Another point of view is given by a comparison of the groups of nerve-cells of the peripheral ganglia with the groups of nerve-cells of the brain and spinal cord. The proper working of the body depends upon an agile response by the central nervous system to what is going on in the periphery. Now the peripheral ganglia are made up of nerve-cells and

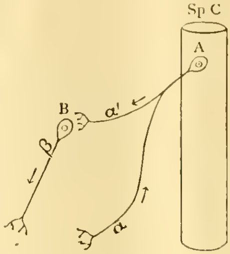
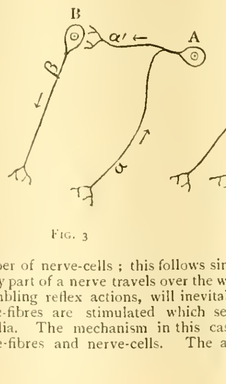



FIG. 2.

nerve-fibres which differ less in general characters from some of the cells of the central nervous system than these differ from one another. The nerve-cells of the spinal cord can receive impulses from many groups of nerve-cells both near and remote; they do not simply receive impulses from one quarter alone—say, the cortex of the cerebral hemispheres—but from many quarters, and notably direct from the periphery. Hence it has been supposed that the peripheral ganglia have similar wide connections, that they receive impulses direct from the periphery, that each is connected with other ganglia, and that impulses received from the periphery, or elsewhere, bring separate ganglia into coordinate action. And this view, which has been taken on general grounds, has been supported by microscopical observations.

The evidence against this view is of two kinds. In the first place, it can be shown that in a number of individual cases the nerve-cells of one ganglion have no connection with the nerve-cells of another ganglion, so that anything like a universal scheme of connection is out of the question. And, secondly, it can be shown that whenever an action occurs, which might be referred to such connection, it is an action which is bound to occur in consequence of some other known arrangement, and that therefore it is unnecessary to seek for a further cause.

The evidence of the first kind we need not enter into; the evidence of the second kind we may hastily touch on. If we accept the conclusion stated above, that the pre-ganglionic nerve-fibres branch, and the branches run to different nerve-cells, it follows that a stimulus applied to one branch will stimulate a



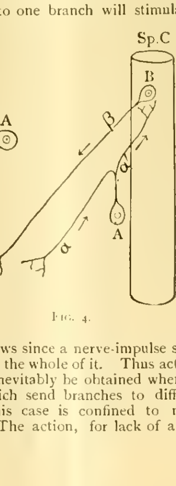




FIG. 3 FIG. 4.

number of nerve-cells; this follows since a nerve-impulse set up in any part of a nerve travels over the whole of it. Thus actions, resembling reflex actions, will inevitably be obtained whenever nerve-fibres are stimulated which send branches to different ganglia. The mechanism in this case is confined to motor nerve-fibres and nerve-cells. The action, for lack of a con-

venient term, was spoken of by Dr. Anderson and myself as a reflex action. It is perhaps better to call it a *pseudo-reflex action*.

Regarded from the customary point of view, a pseudo-reflex differs widely from a reflex action. The one is brought about by stimulating an efferent or motor fibre, and the other by stimulating an afferent or sensory fibre.

But suppose we compare them from another point of view. Fig. 2 is a diagrammatic representation of a pseudo-reflex. A nervous impulse passes up one branch $\alpha$ of a cell A, passes to another branch $\alpha'$, so excites a cell B and its nerve-fibre $\beta$.

Fig. 4 is a diagrammatic representation of a simple true reflex in the voluntary muscle. A nervous impulse passes up one branch $\alpha$ of a cell A, passes to another branch $\alpha'$, so excites a cell B and its nerve-fibre $\beta$.

You see the two can be described in exactly the same terms, and both are reducible to the diagram of Fig 3. It is true that the cells A and B are not similarly situated in the two cases; in the pseudo-reflex A is in the spinal cord, and B is outside it in a peripheral ganglion; whereas in the true reflex A is outside the spinal cord, in a spinal ganglion, and B is inside the cord. But then no one has even suggested that the position of a nerve-cell determines whether an action in which it takes part is a reflex or no. So that this point is irrelevant. And so it might be urged that the one action has as good a title to be called a reflex as the other. I do not, however, wish to insist too much on this comparison. I am inclined to say, after Touchstone, "An ill-favoured thing, sir, but mine own."

If, as some think is the case, the spinal ganglion cell receives the nerve-impulse conveyed by the peripheral nerve process, and modifies it before passing it on to the central process, this establishes a distinguishing character for the true reflex. It would be probably an axon plus dendron reflex, the pseudo-reflex being simply an axon reflex. The important known functional difference between the reflex and the pseudo-reflex is that in the former case the nerve-endings of the primarily affected nerve-fibre are specially differentiated for receiving nerve-impulses, and in the latter case these endings are specially differentiated for imparting nerve-impulses. And, on the whole, it is probable that the pseudo-reflex is not a normal part of the working of the body, but comes into play only as it were by accident. I do not, however, regard this as quite certain.

The pseudo-reflex I have spoken of is caused by the excitation of nerve-fibres before they reach the ganglia—*i.e.* of pre-ganglionic fibres. But the fibres which are given off by the ganglia also branch, so that it appears inevitable that we should have in certain circumstances an action related to a reflex caused by a stimulation set up in one of these branches spreading to the rest—*i.e.* a spreading out of impulses in post-ganglionic fibres similar to that which occurs in pre-ganglionic fibres. Turning to the diagram, Fig. 1, a nervous impulse set up in one branch—possibly by a contraction of muscle-cells to which it runs—would spread to other branches and cause contraction of the muscle-cells in connection with them. You will notice that this spreading out of impulses does not necessarily involve the stimulation of any nerve-cell; it might perhaps be distinguished as *irradiation*. It would, probably, be very local in action, unless there were overlapping of the districts supplied by the several nerve-cells, in which case a not inconsiderable spreading out of a local contraction might take place, giving rise to a peristaltic wave.

It must be pointed out that it has been assumed that in the sympathetic nervous system an impulse cannot pass from a motor fibre through the nerve-cell from which the fibre arises and affect any other nerve-fibre or nerve-cell. There is good ground for this assumption, but the experimental evidence might certainly be more complete.

To return to our main line of argument, we have good evidence that nervous impulses set up in one spot may affect regions more or less remote by a mechanism which does not involve the presence in the sympathetic system of special sensory nerve-cells with peripheral sensory nerve-endings. And so far as investigation has gone at present, I think that all the apparent reflex actions can be explained without reference to such sensory apparatus. And so I take the analogy of the peripheral ganglia with the central nervous system to be misleading, and consider that all the nerve-cells of which we have been speaking are motor nerve-cells, and that they all conform to the simple plan shown in Fig. 1. Thus the whole consists of a duplication of one type; a cell in the spinal cord which branches, each branch ending in a single cell; each of these cells sends off a nerve-fibre which branches, the branches ending in a group of involuntary muscle or gland cells.

That I regard as the real working mechanism, but there are two reservations to make. All the tissues of the body may be looked upon as engaged in a lifelong process of carrying out experiments, and I am prepared to believe that there are in the body what may be spoken of as the residues of these natural physiological experiments, either the beginnings of experiments which have not succeeded, or the melancholy ends of those which once partially successful have failed later. Such possibly may be the nerve-cells which have been described in sympathetic ganglia as sending their nerve-fibres to other nerve-cells.

Secondly, in this account I have not included the nerve-cells which exist in the wall of the alimentary canal, and the cells of Auerbach's and Meissner's plexuses. These "enteric" nerve-cells belong, I hold, to a system different from that of the other peripheral nerve-cells. With regard to their connections I do not think anything can be said with certainty.

*Regeneration. Specific Nerve Energy.*—One other problem presented by this involuntary system we may say a few words about. You know that when a nerve in the hand or arm is cut the nerve will in proper conditions grow again; and the lost feeling and the lost power over the muscles will return. The recovery is brought about by the part of the nerve which is attached to the spinal cord growing along its old track and spreading out as before in the muscle, skin and other tissue. At any rate, that is the method for which there is most evidence. You may know also that when the nerve-fibres in the spinal cord are similarly injured, they do not recover function. Regeneration in the latter case implies that the nerve-fibres have to form fresh endings in connection with nerve-cells. If this were more difficult than the formation of nerve-endings in muscle and other non-nervous tissues, the difference which exists as regards recovery of function between the nerve-fibres of the limb and nerve-fibres of the spinal cord would be readily explainable. But recent experiments show that the nerve-fibres which run from the spinal cord to the peripheral ganglia—*i.e.* pre-ganglionic fibres—re-form with ease their connection with nerve-cells, so that we may probably seek in mechanical conditions for the reason of the absence of regeneration of the fibres in the spinal cord. Possibly some way may be found of improving the mechanical conditions, and so obtaining regeneration. That question, however, we need not enter into.

The regeneration of the pre-ganglionic nerves presents some very remarkable features. The nerve-fibres which end in a sympathetic ganglion are rarely, if ever, all of one kind—that is to say, they do not all produce the same effects. Thus, of those which run to the ganglion in the upper part of the neck, some cause the eyelids to move apart, some cause the pupil to dilate, some cause the face to become pale, some cause the glands of the mouth or skin to secrete, and others have other effects. These different kinds of nerve-fibres run, in large part at any rate, to different nerve-cells in the ganglion. There are in the ganglion several thousands of nerve-cells closely packed together. And it would seem hopeless for each kind of nerve-fibre as it grows again into the ganglion during regeneration to find its proper kind of nerve-cell. Nevertheless, nearly all of them succeed in doing this. The nerve-fibres which normally cause separation of the eyelids, or dilatation of the pupil, or pallor of the face, or secretion from the glands, produce the same effects after several inches of their peripheral ends have formed anew.

The fact offers at first sight a striking proof of a specific difference between the different classes of nerve-fibres and different classes of nerve-cells. Through the matted mass formed by the delicate interlacing arms of the nerve-cells, the ingrowing fibres pursue their tortuous course, passing between and about hundreds of near relations until they find their immediate stock, whom they clasp with a spray of greeting tendrils and so come to rest.

Absolute laws seem unfitted for a workaday world. For closer observation shows that the fibres have not always this marked preference for their own stock. The nerve-fibres of the cervical sympathetic, the nerve I have spoken of above, do not often go astray, at any rate so far as is known. But they do sometimes; thus it may happen that some nerve-fibres which

ought to find their home with nerve-cells governing the blood-vessels, take up with nerve-cells governing the dilator structures of the pupil.

And if we turn to other nerves, greater aberrations are found. We have seen that the nerves running from the central nervous system to involuntary structures may be divided into two sets: the sympathetic nerves on the one hand, and the cranial and sacral nerves on the other. An important cranial nerve is the vagus; it causes, when in action, cessation of the heart-beat, contraction of the œsophagus, contraction or inhibition of the stomach, and various other effects. It does not send nerve-fibres to any of those structures of the head which we have seen the sympathetic ganglion at the top of the neck—the superior cervical ganglion—so liberally supplies. And yet the vagus nerve, if it has a proper opportunity of growing into the superior cervical ganglion, will do so, and there establish connections with the nerve-cells. Thus the nerve which properly exercises control over certain viscera in the thorax and abdomen is capable of exercising control over structures in the head, such as the iris, the blood-vessels and the glands. The details of the process, with which I will not trouble you, do not afford any clear evidence that the nerve-fibres of the vagus pick and choose amongst the nerve-cells of the superior cervical ganglion; the fibres appear rather to form their terminal branches around any kind of nerve-cell, so that, in fact, the action which the nerve-fibre will in future bring about depends, not on any intrinsic character of its own, but upon the nature of the action carried on by the nerve-cell. The nerve-cell may cause secretion from a gland, or contraction of a blood-vessel, or dilation of the pupil, or movement of hairs; whichever action it causes, the nerve-fibre which joins it from the vagus nerve can cause for the future, and it can cause no other. In this case, then, we arrive at results which are hopelessly at variance with the view that the nerve-fibres and nerve-cells of the involuntary nervous system are divided into classes which are fundamentally different. In other words, that theory which is spoken of as the theory of specific nerve-energy does not apply here.

But if this is so, how are we to account for the selective power shown by the sympathetic nerve-fibres which I have mentioned earlier? That the different classes of nerve-fibres and nerve-cells with which we are dealing have not those deep and inherent differences which are required by the theory of specific nerve-energy is, it seems to me, certain. Nevertheless, there may be some differences of a comparatively superficial nature which suffice to explain the selective activity observed. We may suppose that a re-growing nerve-fibre will in favourable circumstances join a nerve-cell the function of which is the same as that of its original cell, but that if there are hindrances in the way of this return to normal action, and if the conditions are favourable for joining a nerve-cell acting on some other tissue, why then it will join this. It is as if it had a preference, but did not care overmuch. We might perhaps express the facts by saying that there are different varieties of pre-ganglionic fibres, but no species.

We have been speaking so far of the nerve-fibres which run from the brain and spinal cord to the peripheral nerve-cells. The nerve-fibres which run from the peripheral nerve-cells have also, there is reason to believe, a large measure of indifference as to the kind of work they perform. The limits of this indifference have yet to be investigated.

I have said earlier that in mammalia nerve-fibres are not known to run to connective-tissue cells or to epidermic cells. But in some lower vertebrates certain connective-tissue cells are under the control of the central nervous system. Thus in the frog the pigmented connective-tissue cells, which play a large part in determining the colour of the skin, can be made to contract or to rearrange their pigment granules—and so change the colour of the skin—by excitation of certain nerves. In all probability, the motor nerve-fibres to the pigment-cells belong to the same class as the nerve-fibres which run to the arteries and to the glands—*i.e.* they belong to the autonomic system. We have seen that unstriated muscle-cells and gland-cells in different parts of the body are by no means equally supplied with motor nerve-fibres, and it may be that in mammals there are certain connective-tissue cells which receive motor nerve-fibres. Further, if it is true, as it well may be, that nerve-fibres which run to a gland are capable in favourable conditions of making connections with a blood-vessel, it is not beyond hope that either kind of nerve-fibre may experimentally, by offering it favourable conditions, be induced to join connective-tissue cells.

The factors which determine whether a particular tissue or part of a tissue is eventually supplied with nerve-endings, and the degree of development of these, are the factors which determine evolution in general. In the individual, it is exercise of function which leads to the development of particular parts; in the race, it is the utility of this development which leads to their preservation. And so it is conceivable that in some lower vertebrate at some time, the autonomic nervous system may have developed especially in connection with those tissues which appear in ourselves to be wholly unprovided with motor nerve-fibres.

I am tempted, before ending, to make a slight digression. Those who have occasion to enter into the depths of what is oddly, if generously, called the literature of a scientific subject, alone know the difficulty of emerging with an unsoured disposition. The multitudinous facts presented by each corner of nature form in large part the scientific man's burden to-day, and restrict him more and more, willy-nilly, to a narrower and narrower specialism. But that is not the whole of his burden. Much that he is forced to read consists of records of defective experiments, confused statement of results, wearisome description of detail, and unnecessarily protracted discussion of unnecessary hypotheses. The publication of such matter is a serious injury to the man of science; it absorbs the scanty funds of his libraries, and steals away his poor hours of leisure.

Here I bring my remarks to a close. I have endeavoured to give as clearly as possible what seem to me to be the conclusions which logically follow from certain data, but I would not have you believe that I regard them as representing more than the immediate point of view. As the wise man said: "Hardly do we guess aright at things that are upon earth, and with labour do we find the things that are before us."

## *AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.*

THE presidential addresses delivered before the Sections of Zoology and Botany of the American Association, by Profs. S. H. Gage and C. R. Barnes, respectively, are printed in *Science* of September 8. The subjects were "The Importance and the Promise in the Study of Domestic Animals" and "The Progress and Problems of Plant Physiology" and the subjoined extracts show some of the points dealt with. Abstracts of several other sectional addresses have already appeared in NATURE, p. 515.

Prof. Gage described a few ways in which the study of domestic animals has thrown light on the problems confronting mankind in his social ideals, in preventive medicine, in physiology and hygiene, in embryology and comparative anatomy and in the doctrine of the evolution of organic forms. He showed that, with the higher forms at least, that is the forms most closely related to man, and with whose destiny his own economic, hygienic and social relations are most closely interwoven, the domestic animals have in the past and promise in the future to serve the best purpose because of the abundance of the material in quite widely separated groups of animals which long have been and still are under greatly differing conditions and surroundings; and, finally, because this material is plentiful and under control, and thus may be studied throughout the entire life cycle.

There has been and still is too great a tendency in biology to study forms remote and inaccessible. This is, perhaps, partly due to the fascination of the unknown and the distant, and the natural depreciation of what is at hand. But study of these supposedly generalised types has proved more or less disappointing. No forms now living are truly primitive and generalised throughout. They may be in parts, but in parts only. The stress of countless ages has compelled them to adjust themselves to their changing environment, to specialise in some directions so far that the clue through them to the truly primitive type is very much tangled or often wholly lost. Indeed, every group is in some features primitive.

As any complete study requires much material at all stages the higher forms must be of the domesticated groups, or wild

forms must be practically domesticated for the time being to supply the material.

It may be objected, also, that in the investigation of domesticated forms sordid interests will play too prominent a part. No doubt to the true scientific man the study of zoology for its own sake, that is, for an insight into the fundamental laws of life, is a sufficient incentive and reward. Judging from the past, the study of the domestic animals in any other way than in a scientific spirit and by the scientific method will prove barren; but studied in that spirit and by that method the result has always justified the effort, and has thrown as much, if not more, light upon biological problems than an equally exact study of a wild form.

Therefore, while purely practical ends can never supply the inspiration to true scientific work, still surely no scientific man could feel anything but happiness that his work had in some ways added to the sum of human well-being. Perhaps no one has expressed so well the sympathy of a scientific man with his fellow-men as Pasteur in the preface to his work on the silkworm diseases: "Although I devoted nearly five consecutive years to the laborious experimental researches which have affected my health, I am glad that I undertook them. . . . The results which I have obtained are perhaps less brilliant than those which I might have anticipated from researches pursued in the field of pure science, but I have the satisfaction of having served my country in endeavouring, to the best of my ability, to discover a remedy for great misery. It is to the honour of a scientific man that he values discoveries which at their birth can only obtain the esteem of his equals, far above those which at once conquer the favour of the crowd by the immediate utility of their application; but in the presence of misfortune it is equally an honour to sacrifice everything in the endeavour to relieve it. Perhaps, also, I may have given young investigators the salutary example of lengthy labours bestowed upon a difficult and ungrateful subject."

In conclusion Prof. Gage summarised his address by saying: However necessary and desirable it may have been in the past that the main energy of zoologists should be employed in the description of new species and in the making of fragmentary observations upon the habits, structure and embryology of a multitude of forms, I firmly believe that necessity or even desirability has long since passed away, and that for the advancement of zoological science the work of surpassing importance confronting us is the thorough investigation of a few forms from the ovum to youth, maturity and old age. And I also firmly believe that, whenever available, the greatest good to science, and thus to mankind, will result from a selection of domesticated forms for these thorough investigations.

In the Section of Botany, Prof. Barnes discussed the chief features of plant physiology in which notable progress has been making during the last decade. The great advances in plant chemics and physics; the progress in the investigation of causes of plant form: the widening ideas of the property of irritability; the investigation of the social relations of plants, and the minute study of cell action in spite of their diversity, have one great end in view. This is nothing less than the solution of the great problem—the fundamental problem—of plant physiology as of animal physiology, namely the constitution of living matter. Entrenched within the apparently impregnable fortress of molecular structure this secret lies hid. The attacks upon it from the direction of physical chemistry and physiological morphology, of irritability, of ecology and of cytology are the concentrating attacks of various divisions of an army upon a citadel some of whose outer defences have already been captured. The innumerable observations are devised along parallel lines of approach, and each division of the army is creeping closer and closer to the inner defences, which yet resist all attacks and hide the long-sought truth.

One outer circle of defences yet remains untaken, and until that falls it would seem that there is little hope of capturing the inner citadel. More must be known of the constitution of dead substances chemically related to the living ones. When the students of chemistry can put the physiologists into possession of the facts regarding dead proteids, the attacks will be renewed more directly, with greater vigour and greater hope of success.

It is not possible to prove to-day that life and death are only a difference in the chemical and physical behaviour of certain compounds. It is safe to say that the future is likely to justify such an assertion.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Eleven county and borough councils have arranged with the Board of Agricultural Studies to make grants for the maintenance of the new department of Agriculture established under the direction of Prof. Somerville. The first list of lectures issued by the Board includes some seventeen courses.

IN the valedictory address delivered by Dr. Hill on vacating the office of Vice-Chancellor, reference was made to the fact that before the close of the academic year the contributions to the Benefaction Fund amounted to upwards of 50,000*l.*; also that a commencement has been made with the new Geological Museum. The Museum will cost about 44,000*l.*, of which sum the fund raised as a memorial to Prof. Sedgwick will supply 27,000*l.*

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A TECHNICAL and mining college is to be established at Wigan at an estimated cost of 40,000*l.*

THE Rev. J. F. Cross has been appointed professor of mathematics at St. John's University, Winnipeg.

PROF. A. MCADIE has been appointed honorary lecturer on meteorology in connection with the Berkeley Astronomical Department of the University of California.

MR. THEODORE MORISON has been appointed principal of the Aligarh Mahomedan College. The new principal, who is at present in this country, has been authorised to select two new professors to take out with him.

PROF. WAGSTAFF will lecture on geometry at Gresham College from October 10 to 13, and the Rev. E. Ledger's course of lectures on astronomy at the same institution will take place from November 14 to 17.

THE degree of Doctor of Pharmacy has just been conferred by the University of Paris for the first time. The recipient is M. Lacourt, whose graduation thesis was entitled "Historical, Chemical and Bacteriological Study of the Versailles Water."

THE fifteen universities of France together have a total of 27,080 students, of whom 12,059 belong to Paris. The total expenditure is 13,859,500 francs, so that the average cost of the education of each student is 511 francs (a trifle over 20*l.*). To meet this expense the universities have revenues amounting collectively to 2,093,700 francs; legacies, donations, &c., amount to 1,511,600 francs; therefore a deficit of 10,524,200 francs (equivalent to nearly 15*l.* for each student) has each year to be made up by the State.

AT the half-yearly meeting of the court of governors of Owens College, Manchester, held on Tuesday last, the following resolution was carried by a majority of two:—"That, subject to such limitations and conditions as the council may from time to time determine, and subject to the council being able to make satisfactory provision for a separate instruction in such cases as the council consider necessary, the court is of opinion that it would be desirable to admit women students to the course of study which would qualify them for medical degrees and practice."

ACCORDING to the Allahabad *Pioneer Mail*, during the past year no fewer than 11,000 candidates presented themselves for the various examinations of the Madras University, and of these slightly over 4000 were successful. The fees paid by candidates amounted to nearly Rs. 1,87,000; while sundry items, including about Rs. 10,000 interest on Government securities, swelled the income of the University to a little over two lakhs of rupees. The total expenditure for the year came up to Rs. 1,80,000, of which sum Rs. 1,38,000 were absorbed by examiners' fees. The Arts Examinations, as usual, yielded the greatest portion of the University income—the total fees realised from candidates amounted to over one and a half lakhs of rupees, while payments to examiners came up to Rs. 90,000. The Law Examinations yielded a quarter of a lakh of rupees, while the examiners fees only amounted to slightly over half this sum. The Medical and Engineering Examinations, however, are conducted at a loss; but, after balancing receipts and expenditure, the University realised a net profit during the past year of Rs. 10,000, without reckoning the Rs. 10,000 accruing as interest from Government securities.

WE learn from a memorandum that has just reached us that the number of students who attended the City and Guilds of London Institute Central Technical College last session was 245. Of these 220 were following the Diploma Course, eighty-eight attending the First Year Course, seventy-eight the second, and fifty-seven the third. Twenty-five other students were either engaged in research work or were following a special course. During the past year the council has conferred the diploma of Fellowship of the City and Guilds of London Institute upon two of the past students: Mr. W. J. Pope and Mr. A. E. Childs. Siemens Medals were awarded to Mr. F. E. Whittle and Mr. F. C. Hounsfield. Mr. T. M. Lowry and Mr. E. C. Jee, were successful in gaining the D.Sc. degree of the University of London for research work done in the Chemical Department of the College. Twelve students of the College were successful in passing the intermediate B.Sc. examination of the London University. In addition to the students admitted on the results of the Matriculation examination, several others have been admitted to special courses of instruction, and the number in the College at the commencement of the new session will be about 260. Those in special courses number 20. As built the College was intended to accommodate only 200 students. To make adequate provision for Electrical Engineering, a large portion of the basement floor in the adjoining new building of the School of Art Needlework is to be used. The suite of rooms now occupied by the Technological Examinations Department will also become available for teaching purposes, as more extensive quarters are to be found for the Examinations Department in the new building. In connection with this institution, our readers may be referred to the address delivered to the students by Sir Andrew Noble, K.C.B., F.R.S., on Tuesday last (see p. 551 of the present issue).

WHEN the history of education in rural districts comes to be written, the school of science established by the united efforts of the Countess of Warwick and Prof. Meldola, at Bigods, near Dunmow, in Essex, will be given an important place in it. The claims of science to form a part of every national system of education are becoming more and more recognised in our cities, but the forward movement has not been much felt in rural districts, hence the school at Bigods is of the nature of an experiment, and much depends upon the success attained. The curriculum followed in the school meets the requirements of modern education in a most efficient way. The school is a continuation or secondary one in which the ordinary "humanitarian" subjects are by no means neglected, but are carried to higher stages. Modern languages are included, and grammar, geography and history find their places. But the noteworthy characteristic of the school lies in the fact that students devote fifteen hours a week to science, which is not taught in the old-fashioned way, by means of books and blackboard and chalk, but by real work and by observations carried on by the pupils themselves in the laboratories and in the fields. The reasoning faculty is developed by scientific methods at the very commencement of the pupil's education at the school; and students who stay at Bigods for three or four years will have acquired knowledge which will be of the highest value in after life, whether they pass into an agricultural college or enter at once into rural or other industries. For the sake of British agriculture, it is to be hoped that parents in East Anglia will appreciate the efforts being made at Bigods to provide a system of education which will assist both individual and national progress.

## SOCIETIES AND ACADEMIES.

### PARIS.

**Academy of Sciences**, September 25.—M. Maurice Lévy in the chair.—Studies on trimethylene, by M. Berthelot. Preliminary experiments were made on the preparation of trimethylene in the pure state, free from propylene, and the gas obtained, believed to be pure, was characterised by its slow reaction with bromine. Propyl alcohol dropped upon hot zinc chloride gives propylene mixed with hydrogen and propane, but almost free from trimethylene; isopropyl alcohol behaves similarly, and the substitution of strong sulphuric acid for the zinc chloride does not result in the formation of any trimethylene.—On the Neomylodon, by M. Albert Gaudry. An account of the discovery of fossil remains in a cave in Terra del Fuego by Dr. Otto Nordenskjöld, the chief being the skin of a large animal resembling the Mylodon, and which has been named Neomylodon by M. Ameghino.—An account of the ceremony organised at Como to celebrate the discovery of the galvanic battery by Volta.—Observations of the sun made at the Observatory of Lyons with the 16 cm. Brunner equatorial during the first quarter of 1899, by M. J. Guillaume. The results are expressed in three tables giving the number of spots, their distribution in latitude, and the distribution in latitude of the faculæ.—A comparison of the times obtained for the contacts of partial eclipses of the sun by direct observation and by measurements of the lengths of common chord, by M. Ch. André.—On fixed transformation points, by M. H. Le Chatelier.—On the diurnal variation of atmospheric electricity, by M. A. B. Chauveau. From the results of observations made at the summit of the Eifel Tower, it is found that the true law of variation is given by a simple oscillation with a maximum in the day time, and a very constant minimum at 4 to 5 a.m. The more complicated curve obtained by observations in an ordinary building are probably due to the influence of water vapour.—On a particular mode of reproduction of appendices of insects in course of regeneration after artificial section, by M. Edmond Bordage.—On the lateral cephalic organs in *Glomeris*, by M. N. de Zograf.—Some phenomena of cellular disorganisation, by M. Vital Boulet. The asmotic pressure in the cells of a leaf severed from the plant and left in the same water as that in which the original plant was growing was found to regularly increase from 2·2 on the first day to over 6·0 on the twenty-second day.—On the formation of secreting canals in the seeds of certain species of *Garcinia* and *Allanblackia*, by M. Édouard Heckel.

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THURSDAY, OCTOBER 12, 1899.

## VERWORN'S "GENERAL PHYSIOLOGY."

*General Physiology. An Outline of the Science of Life.* By Prof. Max Verworn. Translated from the second German edition by Dr. Frederic S. Lee. Pp. xvi + 615. (London: Macmillan and Co., Ltd., 1899.)

WE cordially welcome the appearance of an English translation of this well-known book. The first (German) edition appeared in 1894, and was noticed at some length in this journal (vol. li. p. 529). The in erest which it excited is testified to by the practical fact that a second edition in German was called for in 1897, while translations into English, Italian and Russian have also appeared.

The second edition differs from the first only in detail. The general plan remains the same, though, as the author remarks in the preface, the more important results of the very large number of researches in the physiology of the cell which have appeared during the last few years have been added.

The scope of the book is "an attempt to treat general physiology as general cell-physiology," and thus to outline a field in which the various branches of special physiology might unite. The author is at some pains to define the cell as the unit of organised living matter—the smallest part which can maintain an independent existence; it is the "elementary organism." Having described this unit, and discussed its structure and chemical and physical constitution and the way in which the substance of which it is composed differs from non-living substance, the author proceeds to a consideration of the phenomena which are manifested by cells in general. He is thus led to a discussion, firstly, of the internal phenomena of life in their most general aspect—of change of substance or metabolism, of change of form, and of change of energy; and, secondly, of the external relations of living matter, of food, of effects of temperature, &c., of stimuli, of the origin of life on the earth, and of the process of dying. Lastly, he returns to a consideration of the nature of the material of the cell, and seeks there an explanation of these internal and external phenomena. These inquiries are sufficiently wide; but the author, not content with them, includes an interesting history of physiological research, in which he rightly endeavours to justify his own standpoint by an appeal to the development of the science; and a discussion, in true Ercles vein, of the relation of physiological research to metaphysics in which, among other things, the investigator is invited to "get rid of the error of the existence of a physical world outside the mind"!

Those who have made acquaintance with Prof. Verworn's views in other and earlier publications, as, for instance, in papers published in the *Monist* (*cf.* NATURE, li. p. 58), will not be surprised to learn that the tone of the book is somewhat aggressive. He has set himself the task of recalling physiologists from the barren field of "one-sided specialisation," whatever that may mean, to a renewed consideration of the ultimate problems of life. He is impatient with the "impotence of the physiology of to-day in the presence of the simplest vital processes." The outworks are down, why do the workers stay prying into the ruins when they should press on to attack the central citadel, the cell, wherein the simple secrets of these simplest of processes are hidden?

No fault can be found with the purpose which is outlined here, but unfortunately the reader's sympathies are apt to be lessened by a lack of restraint and reticence in the advocacy. There is an unpleasant tone of special pleading running through the pages, which inevitably raises the suspicion that the author's outlook is perhaps not so broad as he would have us believe.

A good wine needs no bush, and the virtues of an endeavour to bring together all that is known of the general properties of living matter suffer when heralded by an impeachment of the past achievements of physiology which is phrased so as to convey the idea that the nature of the processes which constitute life has not been touched on. In point of fact, the knowledge gained, amongst other things, of the internal respiration of muscle, of the automatic phasic activity of the cardiac and other tissues (due, by the way, mainly to the work of Gaskell, and not to that of Engelmann, as the author states), and of the special processes of storage and discharge in glandular organs, has led to a first approximate conception of the character of the changes, both in matter and energy, which waits for further development, not upon the labour of biologists, but upon that of workers in the domain of molecular physics.

It is possible that the central idea of the book—the assertion of the identity of general physiology with cell physiology—is founded upon a misconception, and we are inclined to doubt whether any special virtue is likely in the future to flow from the study of the cell. If the cells in question form part of tissues or organs, then the methods are the methods which have been employed in the past. The study of the cardiac muscle cell is the study of the heart, of the secreting cell that of the gland which holds it, and so on. Practically, as one learns by perusing Prof. Verworn's pages, what is really new in his method is confined to the exaltation of the importance of the study of the cell when it is an independent individual, such as one finds in the members of the Protozoa. In this field he has himself laboured with no small measure of success. The phenomena exhibited by free-living cells are unquestionably of surpassing interest, but, unfortunately, the study of the relatively diffuse activities which they manifest must be of secondary importance, seeing that the facts which are gleaned can only be interpreted by the aid of that insight into the finer anatomy of function which springs from a study of the highly specialised organs of the higher types where the activities of living matter are, as it were, analysed for us.

This is not the only drawback. There is another, and perhaps more serious one, which the author nowhere stops to discuss. It lies in the difficulty which exists when minute forms are used for experiment in deciding how far a given result is a true physiological reaction to a stimulus, and how far it is a purely mechanical effect. For instance, under the heading of galvanotaxis, and in the section dealing with the general effect of electrical stimuli, a description is given of the way in which animalculæ become grouped round one of the poles, while individuals suffer actual alteration in shape under the influence of a

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constant current. But, as Faraday was the first to show, small particles of any kind are driven to one or other pole when suspended in fluid through which a current is passed, and a rod of jelly suffers compression at one end and expansion at the other under the mechanical stresses produced by the passage of a current.

The general tone of the book is inspired by an impatience with the laggard pace of knowledge—the "foster-child of silence and slow time," if one may wrest a phrase of Keats from its setting—which prompts the taunt that the physiology of to-day is impotent in face of the simplest vital processes. Unfortunately, it is not controlled by a true feeling for the relation of the knowledge of living matter to the progress of the general knowledge of matter. The tools with which the attempt to fashion a dynamical explanation of the phenomena of life must be made are themselves still in the making. It is barely ten years since what was practically the new science of molecular physics was founded at the meeting-place of chemistry and physics by the labours of Guldberg and Waage, Arrhenius, van 't Hoff, Gibbs, Ostwald and others. On the growth of this science the biologist must wait, and, though the advances which it has made are prodigious, they are concerned wholly with the crystalloid type of matter—they have not yet embraced the colloid type which is the physical basis of life.

The completeness of our ignorance of the latter type is manifested with almost dramatic force when one finds all that is known of colloidal matter lying in the compass of a page or two of a text-book such as that of Ostwald or of Nernst, whereas the account of the crystalloid type stretches to many hundreds! Reproaches and hasty generalisations are equally out of place in the face of this colossal ignorance of the elements of the problem; and one feels the practical wisdom of physiological workers in devoting themselves to what may be called the anatomy of function—that is, the interpretation of organ and tissue activities in terms of the fundamental properties of living matter, rather than in kicking against the barriers which the general state of knowledge opposes to the translation of these fundamental properties into terms of matter and motion.

The same lack of a sense of the historical position of biology caused Bunge to drift into vitalism, which at any rate has the merit of recognising the difficulties which stand in the way of a dynamical explanation of metabolism, irritability, and the recurrent cyclic character of the phenomena of life.

Prof. Verworn, however, is impelled to the opposite extreme—a materialism, often rash, which leads him to a disastrous quest for "simple explanations," in which his knowledge too frequently becomes wire-drawn to the breaking point. The "mechanical explanation" which he offers of the "so-called" selection of food will serve as an instance. A cell bathed by a nutrient fluid such as, *e.g.*, an epithelial cell absorbing material from the lumen of the intestine, is likened to a crystal growing in its mother liquor. Like its analogue, it withdraws only special substances from the common nutrient fluid, "as is evident from the fact that gland, muscle and cartilage cells produce wholly different and characteristic substances." Hence the conclusion that the selection of food is only a special manifestation of chemical affinity, and that "it is an absolutely necessary consequence of the fact that the living substance of every cell possesses its own specific composition and its own characteristic metabolism." So in place of the healthy recognition of a difficulty we are offered a cumbrous platitude and a leap in the dark!

The simple explanation which is offered of the fact "which must otherwise appear very wonderful" (*sic*), that among the innumerable swarm of spermatozoa cast into the sea, every species finds its proper ovum, also deserves mention. It "is explained very simply by the further fact that every species of spermatozoon is chemiotactic to the specific substances that characterise the ovum of the corresponding species." The robe of modesty is more fitting than the gown of counsel for explanations like these!

In other cases the haste for simple explanations leads to a mode of treatment of problems of acknowledged difficulty which intensifies the obscurity. Thus some space is devoted to urging that there is no distinction between the motor impulse or the electric current in their action upon, for instance, muscle fibres and that relation between motor nerve cell and muscle fibres which, when it is broken by severance of the connecting nerve, causes degeneration of the latter. This view is distinctly opposed to the results of recent work upon muscular tone, and upon the effects of section of the roots of spinal nerves which tend to emphasise the distinction between the calling out of special activity by special nervous impulses and the fact that many highly specialised cells are dependent for their continued well-being, even for their capacity to respond to stimuli, upon their functional continuity with other and totally dissimilar cells. We are ignorant of the nature of the latter relation, though it may well be one of simple dynamical equilibrium rather than one dependent upon the passage of nervous impulses. But Prof. Verworn starts in a panic from this unsolved problem. He sees in it a piece of the old mysticism of the vitalists, and, in order to compass a simple explanation, trophic relations are grouped with the action of electric and chemical stimuli and of food into one class which lacks both order and form.

In spite of these defects in general tone, the pages of the book furnish abundant justification for the success which it has already attained. The point of view which the author has adopted has led him to bring together a body of facts, many of them little known, in a manner which cannot fail to be stimulating and suggestive to both physiologists and morphologists. Many gems of thought, too, are to be found, especially in the later chapters. The sections on the directive effects of unilateral stimulation, chemiotaxis, barotaxis, &c., are singularly interesting, and so too is the conclusion which is drawn from the facts, namely, a general application of the principle of the specific energy of sense-substances.

> "All living substance possesses specific energy in Müller's sense: with certain limits wholly different stimuli call forth in the same form of living substance the same phenomena, while, conversely, the same stimulus in different forms produces an effect wholly different and characteristic for every form."

The treatment of the dynamics of movement as a polar change in the resultant of the anabolic and katabolic processes in the cell, or "biotonus," as the author calls their algebraical sum, is equally illuminating, as are also parts of the mechanics of cell metabolism.

The pages dealing with actual facts, which after all make up by far the greater part of the book, possess an enticing feeling of freshness and novelty which is born of the fact that the author's special studies have lain out of the beaten track. For this and for the intrinsic interest of the facts themselves we feel grateful to him, and we heartily wish success to the English edition. The translation bears abundant evidence of the care which Prof. Lee must have lavished upon it. It is a monument of clearness throughout. W. B. HARDY.

## OUR BOOK SHELF.

*Living Pictures.* By H. V. Hopwood. Pp. xii + 275. (London: *The Optician and Photographic Trades Review*, 1899.)

THIS is a very interesting review of the gradual evolution of the various instruments which have been invented for the portrayal of objects in motion, from the earliest times to the present day. The work may be divided into two parts, of which the first, including Chapters i.–iii. (pp. 1–109) deals with the more distinctly historical aspect of the subject, while the remaining chapters (iv.–vii.) are devoted to a very minute description of all the important machines in present use.

Chapters i. and ii., on the "Persistence of Vision," &c., contain a lucid account of the principles governing the phenomenon of a succession of different views of the same object giving the impression of the object being in motion. In this part all the instruments, whether as toys or scientific apparatus, are described in the order of their invention, beginning with the simple colour tops and thaumatrope put forward as early as 1826. The host of improvements from this time up to about 1878 were attempts to remedy the difficulty of so small a percentage of light passing the two slits at first used for the intermittent view. This section concludes with descriptions of the modern mutoscope and viviscope.

Chapter iii. (pp. 43–109) commences with the invention of "chronophotography," and gives a complete description of the more important of the inventions brought out from 1865–1895. The mechanical details in connection with the alternate exposure and movement of the sensitive surface receive special attention, the difficulty of following these being greatly lessened by the numerous illustrations accompanying the text.

Chapter iv. is devoted to present-day apparatus, and all the machines which have appeared before the public receive ample notice, in most cases accompanied by a woodcut showing the internal arrangements.

Chapters v. and vi. deal with the processes adopted in making the films, their exposure, development, printing, &c., and also give ample practical instructions for exhibiting the pictures in the lantern.

At the end of the volume two most useful appendices are given. The first is a "Chronological Digest of British Patents," giving a short *résumé* of all specifications taken out in connection with living pictures from the time of Fox Talbot (1851) to the end of December 1898.

The second appendix is an annotated bibliography of all publications (British and foreign) from 1825 to the present time, which bear on the subject.

The numerous illustrations (242), which are well chosen and very clearly printed, render the following of the necessarily somewhat technical matter exceedingly interesting even to the non-expert. The book will be welcomed by many to whom the methods of cinematography are a mystery, as by its aid any one even strange to the subject may easily understand the working of any of the machines in past or present use.

*Tables and Data.* By W. W. F. Pullen. (Manchester: Scientific Publishing Company, 1899.)

IN these eighty-seven pages Mr. Pullen brings together tables and data which will be found very serviceable in engineering laboratory work and in the solution of class problems and exercises in mechanical engineering. Points perhaps of special mention are that the general steam table is carried up to 300 lbs. per square inch; the diagram for determining the dryness of steam with the throttling calorimeter is plotted on a large scale, and the melting points of various substances has been revised by Sir William Roberts-Austen. For facility of reference the British and metric measures are placed side by side. The remaining portion of the book is devoted to mathematical notes on mensuration, geometry, trigonometry, &c., with a synopsis of mathematical data. At the end are added a few extra pages, some of which are blank, while on others are printed diagrams of millimetre paper, for the insertion of any additional curves the student may wish to insert. Not only engineering students, but others should find the contents of this book a useful laboratory *vade-mecum*.

## LETTERS TO THE EDITOR.

*[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.]*

### Halo Round a Shadow.

IN your issue of this week Prof. S. Newcomb draws attention to the halo which an observer often sees round the shadow of his own head when the ground on which the shadow falls is covered with vegetation or any obstructions which can themselves cast shadows.

In a letter to NATURE in 1878 or 1879 (I have not the reference by me) I mentioned this phenomenon, giving the same explanation as your recent correspondent, and adding that the angular width of the halo was settled by the ratio of the mean diameter of the obstructions to their distance from their own shadows.

The halo (or spot of light, if the observer is too far off for his own shadow to show) can be seen very well when the ground is covered with heather or bracken whose twigs and leaves are small compared to their height above the ground.

3 Victoria Street, S.W., October 6. A. MALLOCK.

### The Skull of Hatteria.

IT may be worth while to draw the attention of naturalists to an omission in the figures of the skull of that archaic reptile, the Tuatara, that occur in two recent text-books of somewhat wide circulation, viz. Parker and Haswell's "Text-Book of Zoology" and Reynolds's "The Vertebrate Skeleton." These figures are either copied or redrawn from Zittel's figure published in his well-known work on Palæontology. This figure appears to have been drawn from an imperfect specimen, as the "transverse" (or transpalatine) bone is omitted in the ventral view; it is *apparently* represented in the dorsal view, however, though there is no index line in the original. The bone, though of considerable size, very readily drops out of a thoroughly macerated skull, from which the figure was no doubt drawn. There is really no excuse for our English authors borrowing the figure from a German book in this instance, for Dr. Günther's picture of the skull published in the *Phil. Trans.*, vol. clxvii., is perfectly accurate, except in regard to nomenclature of some of the bones, while Zittel's is most indistinct.

Dunedin, N.Z., August 30. W. BLAXLAND BENHAM.

## *THE BEST EDUCATION FOR AN ENGINEER.*[1]

An admirable address, well thought out, well delivered, and received with bursts of applause, which were so enthusiastic that they sounded like volleys of musketry. We are still in the early days of the history of technical education, and such deliberate expression of opinion by those who are connected with the engineering industry are much needed on the subject of the early training of the engineer; and when the speaker is Sir Andrew Noble, in whose works 30,000 gain their living, and when, in addition, he says what he really thinks, and does not merely confine himself to complimentary remarks about the College in which he is speaking, his address cannot fail to command close attention.

On two important occasions captains of industry, when referring to the early education of those who afterwards go to the City and Guilds Technical Colleges, have enlarged on the value of a classical training—Mr. Alexander Siemens in 1892, and now Sir Andrew Noble. Now, why is this?

A considerable proportion of those who have made their mark undoubtedly received a classical education, but one asks, Was it the classical education that made them famous, or was it their great natural ability, and consequent success, that made the reputation of classical education? Or is there some other and deeper reason for this advocacy of the study of the language and literature of the peoples who, near the beginning of our era, occupied a small portion of the earth as we now know it? Not certainly the argument so frequently urged—urged even by Sir Andrew Noble in this address—that a student of science should study classics to better understand the meaning of scientific terms. This will teach him that "geometry" means "land surveying," and leave him disappointed that six books of Euclid do not enable him to measure an irregularly shaped field; his Greek will tell him that a "logarithm" is a "proportion number," but a book of them will still be Greek to him. That it is a mĭcrophonē that is used in sending a message to a tēlĕphonē will provoke a laugh from the man in the street, and if to a knowledge of classical grammar the student of science adds that of his own language, he will realise that one reason why it is so difficult to obtain a "reliable" measuring instrument is because such a thing is impossible, for the verb "to rely" must be followed by the preposition "on."

No! such a utilitarian argument in favour of classical study is rather a confession of weakness. Nor—as is so often alleged—is a classical study of importance because it facilitates the learning of modern languages. For many are the Dutch, the Poles and the Russians who talk with exasperating volubility in one's own language, wherever one may have been born, but who know less Greek and Latin than an Eton boy whose linguistic powers are as insular as himself.

A study of the classics and a public school education are frequently regarded as synonymous, and so the advantages of the one are confounded with the advantages of the other. At the present time, when so much attention is devoted in secondary and technical schools to *matter* rather than to *manner*, when the aim apparently is to turn out scientific encyclopædias rather than fairly well-informed people with cultivated manners, the following opinion expressed by Sir Andrew Noble should be taken to heart by every engineering student:

"Speaking as an employer of labour, I should say that we find a pleasant speech and manner, tact in dealing with others, and some power of organisation of the utmost value; and it is precisely those qualities which a boy acquires, or ought to acquire, in his *later* years at a public school. Without such qualities even the highest scientific attainments will never make a captain of industry, and in selecting candidates for appointments the man of business distinctly prefers a youth who has had the benefit of some years at a good school."

But this polish, we urge, might equally well be acquired were the study of Japanese or the production and use of the electric current, or the action of mechanical forces, substituted by a *thoughtful* teacher in a public school for that of Greek and Latin. For that cultivation, which we all value so highly, is not produced by the association of a lad with *dead* writers of exceptional ability, but with *living* lads of his own standing, coming, like himself, from homes where refinement and right feeling pervade, and all, like himself, bent on preserving a tradition which, though sometimes foolish, sometimes rough or even brutal, still tends on the whole towards civilisation. It is not so much the *study* as the *life* of a public school boy that is so valuable in forming his character.

But if that be the case, is Sir Andrew justified in deducing the following conclusion?

"My own impression with regard to early education is that, as a sharpener of the young intellect, and as a mental discipline, it would be difficult to improve upon the curriculum which is now in force at our public schools, and which, in the main, has been in force for so many centuries."

The curriculum of a public school is, we think, not exempt from the rule that what man has devised can always be improved. A classical education, the staple of the public school curriculum, has undoubtedly the great advantage that some of the greatest thinkers in the past spent the early part of their lives in receiving it, and the latter portion in giving it to others. It is, therefore, the particular form of training that has been carefully thought out, and its development is the result of long years of trial and error. Further, it possesses another advantage, the value of which does not seem to have received the recognition it deserves, and this is that when the merest dullard is puzzling out some passage with the aid of dictionary and grammar, he is really engaged in a small way on precisely the same kind of work that enchants the greatest scientific investigator, viz. finding out for himself something that he wants to know.

Now this by no means characterises the work of all the students in a well-fitted modern laboratory. Not a few, following the instructions, spend hours taking readings of instruments and tabulating the results, but fail to find out what is the meaning of these results, or even what is the object of the experiment itself. They have, in fact, been laboriously grinding at the handle of the barrel organ, but have been mentally deaf to the tune that it played.

Heartily then do we join with Sir Andrew Noble in deprecating training of this kind—whatever it may be called—and agree with him that even when all technical study is postponed until after school and college life:—

"Those men who, with fair abilities, have received a really good education, have been taught to use their minds, and who, by contact with other students, have acquired habits of application, amply make up for their late start by the power of mind and grip that they bring to their work."

But can these qualities, we ask, only be acquired by confining a boy's attention to the study of words and ideas, and by excluding all study of nature and things? Sir Andrew himself states:—

"In nine cases out of ten, I should say, any knowledge acquired by a boy before he is sixteen can have but a slight intrinsic value. Up to that age, it is not *what* he learns that we have to look at, but *how* he learns; it is the habit of discipline, of mental application, of power in attacking a subject, that are so valuable; not, generally, any definite piece of knowledge he may have gained."

Now surely "the habit of discipline, of mental application, of power in attacking a subject" is exactly what

[1] Inaugural Address of the Session 1899-1900 of the City and Guilds Central Technical College, given at the College, Exhibition Road, by Sir Andrew Noble, K.C.B., F.R.S., on Tuesday, October 3.

can be learnt from a *proper* study of science, and, so far from any knowledge acquired by a boy before he is sixteen having but a slight intrinsic value, is it not a fact that all knowledge requiring mechanical dexterity, such as reading, writing, arithmetic, riding, swimming, talking foreign languages, playing a musical instrument, &c., can be far better acquired before the age of sixteen than later, and are not all these examples of knowledge possessing intrinsic value?

We are, however, quite at one with Sir Andrew in thinking that

"the age at which a boy should seriously begin any special studies, with a view to fit him technically for the profession he may have decided to follow, should not be earlier than seventeen or eighteen."

But should not a sharp distinction be drawn between learning technology and acquiring the elementary principles of science? His warning that the zest for your life's work may be weakened by embarking on it too early certainly furnishes a potent, probably the most important, reason why lads who intend to become engineers should wait until they are eighteen, or at any rate seventeen, years old before they commence their professional education; for then, as is said in the address, they will be

"fresh and keen when others, who have been hammering away at semi-technical work from early boyhood, have become stale and are less vigorous."

For the same reason also, time devoted by a lad to learning off strings of scientific facts would be misspent, but not so, we think, would time given by even a child to the acquisition of scientific habits of thought. We do not defer teaching a lad the principles of morality until he is seventeen or eighteen for fear he should become tired of living a moral life, why then should the risk that a lad might weary of leading an intellectual one frighten us into excluding the principles of science from a good education?

In the address, "science, mechanical drawing, and such like" are classed together as things that may with advantage be omitted from the training of a lad before entering Elswick, provided he has had a good education. But can an education of the present day be termed "good" which lacks a training in those mental qualities which are classed under the head of scientific?

Great stress was laid by Sir Andrew Noble on the value of the knowledge which a person has gained for himself. He cited the results which "dauntless energy, untiring industry and patient search after truth" had achieved for Lord Armstrong, Watt, Stephenson and Faraday, but only as a proof "that a special technical education is not an absolute necessity." Do not the lives of these men, however, teach us much more than this, viz. that the particular system of education, classical, mathematical, scientific, artistic or technical—in fact, any system of education ever invented—is less than nothing in enabling a man to rise to the top in comparison with the determination to succeed and the brains to do it?

The reason why certain branches of industry have almost abandoned this country, and why new branches that have been developed abroad have hardly taken root with us, is a topic deeply interesting to the manufacturer, but generally rather distasteful to the student, since he would prefer to be told that everything was done better, more cheaply and more expeditiously in his own country than in any other. Sir Andrew Noble, however, made even the part of his address which dealt with this subject appeal strongly to his audience, and for a remedy he thought that it was

"to theoretic and technical knowledge that we must chiefly look. Consider, as an illustration, electricity in the service of man. Think of its innumerable applications, and of the number of hands dependent upon its industries. But for one man capable of designing or improving these powerful machines or delicate instruments, there are a thousand ready and able to carry out their designs. But it is the former who are the salt of the earth, and those who have the management of large concerns know well how to value them."

His patriotic statement (for it is true patriotism to help your own countrymen to learn the truth even if it be distasteful) that the success of our German competitors was *not* due "to their putting on the market inferior goods specially got up to imitate those of a superior class," but "to the far greater opportunities of technical study which are afforded in Germany," was as bold as we believe it to be true. For we were recently informed by an English manufacturer that certain things manufactured in England are now being stamped "Made in Germany," in order to obtain a readier sale for them in our own country.

But in addition to greater facilities being needed in Great Britain for the study of the applications of science to industry, greater belief in the value of such study is wanted, not only on the part of the English manufacturer, but also on the part of the English student. "You younger men," said Sir Andrew, "must do your part by seeking to avail yourselves to the uttermost of any such opportunities provided," and it might be added that the reason why that future "important commercial rival, Japan, is developing its manufacturing powers with an energy that is as remarkable as it is unexampled" is because even thirty years ago its young students absorbed with eagerness and rapt attention every scrap of scientific teaching which they could obtain. And they did so partly for their own personal benefit, but far more because each one felt that on his own exertions depended the fame and future of his mother country. W. E. A.

## RESEARCH WORK AND THE OPENING OF THE MEDICAL SCHOOLS.

IN one sense at least, viz. his intellectual life, the medical student, natural enough in other respects, seems somewhat at variance with nature; his intellectual spring occurs simultaneously with nature's autumn. Brown October sees him change the abstractness of the class-room for the concreteness of the laboratory. Further, each successive autumn, after a period of summer hibernation, marks the advent of some change in his studies. The fully fledged doctor, too, whose daily round obliterates all distinction between term time and vacation, becomes infected in October with a revival of intellectuality, and whets his appetite by an attendance at the inaugural address delivered at his school, where he gets new knowledge or old dished-up afresh, and becomes generally imbued with the spirit of the time.

This year at least the medical student will not be able to lay any shortcomings which may occur during the ensuing academical year to the charge of insufficient or inadequate advice at its onset. At both the London and provincial schools the inaugural addresses, with regard to depth of meaning and also attractive eloquence, have left little to be desired.

In a short article such as the present it would be impossible to adequately reproduce, even in the most abridged form, the various "motifs" pervading the speeches delivered. One, however, constantly recurring, may be somewhat enlarged upon. Here and there and everywhere in the inaugural addresses we find the position of research to medicine and the medical profession cropping up. Occasionally this subject is mooted in the grossly material form, when, for instance, Sir James Crichton Brown frankly told his hearers at Manchester that although 70,000*l*. was an adequate sum so far

Manchester must be prepared to put its hand in its well-lined pocket for an equal amount to keep pace with science, which is now so mobile and so expensive. Dr. Clifford Allbutt delivered an address at St. Thomas's, which mostly consisted of a strictly logical defence of theory and abstract learning. Those who read carefully Dr. Allbutt's address will find more in it even than this. The apostles of empiricism, to whom the almighty fact is alone of importance, are the worst enemies of what may collectively be termed medical research. Their bourgeois utilitarianism prevents them from appreciating or forwarding any branch of inquiry connected with the medical sciences which does not immediately result in something of use. Research to them is the quintessence of an abstractitude.

This mental attitude of a part of the profession, which fortunately is getting less and less, finds its expression in the position adopted by the influential public and lay committees. It is somewhat anomalous—at any rate, it appears so—that astute financiers, practical men accustomed to weigh the chances of ultimate dividends in the most complicated concerns, should so discount pathological and pharmacological research. It must be known to them that a large proportion of the drugs they take, and the curative remedies they employ, are made in Germany, and that thousands of pounds are spent annually on German products of this class which might perfectly well be produced at home. Those of them who wander so far from the Stock Exchange as St. Dunstan's Hill will find there a whole colony of German firms which supply these articles. A public which will wait for years for dividends so far as concerns South African securities, which will fill up readily the gaps in a Cape to Cairo railway scheme, although this at present can only be done by a somewhat lively imagination, is inclined to push and accelerate the scientific worker, and expect maximum results in minimum time. The success of the German manufacturer in products such as therapeutic sera and synthetic drugs is simply due to the fact that the German capitalist has waited for his dividends which he is now getting. Apart from the standpoint of mere commerce, it is somewhat galling to know that a crude product like coal-tar is at present exported from this country, and re-imported worked up in the shape of dye-stuffs and drugs.

To work one must have a workshop; a palace one does not need. This forms another great difficulty with regard to medical research in London. The authorities at the London hospitals rightly regard the patients as having the first charge upon the space and accommodation at their command. Space in London, especially so far as concerns the older foundations—such, for instance, as St. Bartholomew's and Guy's—is necessarily very valuable. This subject formed the keynote of some of the speeches at the old students' annual dinner at St. Bartholomew's. The Great Hall was full of old Bartholomew's men, who, under the chairmanship of Dr. Lauder Brunton and the secretaryship of Mr. Bruce Clarke, met to inaugurate the new academic year. Dr. Lauder Brunton, in a short but effective speech, proudly stated that the hospital, so far as its essentially medical aspect went, left nothing to be desired; quite so much, however, could not be said for the laboratory accommodation. Sir Norman Lockyer, whose opinion upon the subject of experimental technique ought certainly to be final, also deplored this want of laboratory space in so old and famous a medical school. Many difficulties special to medical research were discussed by Sir Norman, and research in this branch of knowledge was compared to research in the physical sciences. One of the difficulties was the question of time. The worker in the fields of the medical sciences must solve his problems often at once. He must be an opportunist. Stars and planets remained more or less the same, but this was not so with disease. Pressure from without, according to Hunter, causes hypertrophy or overgrowth, pressure from within atrophy or waste. If the pharmacological laboratory at St. Bartholomew's is not in a condition of healthy overgrowth, it is certainly not because pressure from without is wanting, for, according to Dr. Brunton, its confines have been narrowed down to some fourteen square feet. It was reassuring to be informed by the treasurer, Sir Trevor Lawrence, that arrangements were on foot which would ensure more ample accommodation to laboratory workers at Bartholomew's.

The London Hospital was fortunate in securing the presence of Dr. Haffkine, who made an excellent and humorous speech. The St. George's students were addressed by Dr. Howship Dickinson upon "Medicine Old and New." Dr. Mitchell Bruce, at Charing Cross, took the "Outlook of Medicine" as the subject of his address. This was, he said, at the present time hopeful, since the scientific method was being pursued in every department of medicine.

In laying stress upon the special difficulties of the time, one is perhaps rather apt to forget the causative origin of all the inaugural addresses, viz. the medical student himself. He comes in ample numbers, a sufficient testimony to the healthiness of the profession he aspires to join, from year to year, sometimes partially prepared by the universities, sometimes raw from school, to struggle with those life-long difficulties of the healing art, compared to which even examinations count as nothing. For five years, now, he must suffer many things of divers examiners, and finally emerge to meet the great problem of his life—the human individual, both healthy and diseased. Exact knowledge in the sense of physical exactitude will probably be denied to as yet many generations of medical students, even concerning the main problems of disease, and in spite of the progress that, thanks mostly to careful and continual laboratory work, often of an apparently abstract nature, has during the last century been made, our knowledge even now serves often merely to illuminate our ignorance, and however optimistic our hopes for the future we are forced to admit that—

A thousand things are hidden still,
And not a hundred known.

F. W. T.

## DARK LIGHTNING FLASHES.

IS there such a phenomenon as dark lightning? This is a question that has often been raised, and as yet no satisfactory answer has been given. If dark flashes do really occur, then they should probably be both seen and photographed, and the former, one would think, would be the more simple way of recording them. A difficulty, however, here arises, for if we assume that both dark and bright flashes occur during a thunderstorm, then we must be careful not to mistake retina-fatigue dark flashes for actual dark flashes if they exist. Lord Kelvin (NATURE, vol. lx. p. 341) has lately pointed out how, during a recent storm, he was able to confirm the existence of these *apparent* dark flashes; and in a more recent number of this journal (vol. lx. p. 391) I published some observations corroborating the same view. It must be pointed out, however, that, although such observations indicate that the majority of dark flashes seen may be attributed to the cause of fatigue of the retina, it does not necessarily follow that dark flashes do not actually occur. Eye observations, therefore, do not help us as yet to give a satisfactory answer to this question.

Let us turn now to photography, and see what evidence we can gather from photographs of flashes taken during thunderstorms.

In dealing with this mode of recording flashes, we are

again confronted with many difficulties, for the action of light on the sensitive film is capable of giving us both bright and dark images, although the object photographed is bright. We have, therefore, to contend with reversals, double reversals, &c., and many as yet unknown factors.

There is one point, however, that stands out foremost, and that is that the photographic plate has recorded many times dark as well as bright flashes; but whether the dark flashes are due simply to some action relative to the sensitive film, or are actual images of real dark flashes, is the very question that has so recently been revived.

What we really are greatly in need of is more data, and when a sufficient number of photographs of all kinds of lightning has been collected, more light will be thrown on this subject. Up to the present time, as each curious photograph of dark lightning was published, suggested theories as to the cause of the peculiarity of the flash have been by no means few in number, so that now the number of hypotheses equals, if not exceeds, that of the photographs examined.

In a very interesting article in this journal (vol. xlii. p. 151), which is an extract from a lecture on "Electrical Phenomena in Nature," delivered by Mr. Shelford Bidwell at the London Institution, the so-called "dark flash" is referred to in these terms.

"It occasionally happens that, on developing a photographic plate which has been exposed during a thunderstorm, the image of a lightning flash comes out black instead of white. . . . There is no need to discuss the several ingenious hypotheses which were suggested in explanation of the anomaly; it is sufficient to say that the mystery was completely cleared up a few months ago by the experiments of Mr. Clayden."

As I have no reference to Mr. Clayden's experiments at hand, I will quote from the above-mentioned abstract a brief summary of his hypothesis as described by the same writer.

"If the lens of the camera be covered the moment after a flash has occurred the developed image will always come out bright, feebly or strongly, according to circumstances. If, however, the plate be exposed after a flash has acted upon it, either to the continued action of a feeble diffused light or to the powerful glare arising from one or more subsequent flashes, then on development the image of the original flash will probably come out black. The effect is therefore not a meteorological or physical one, but purely chemical. It can be obtained, not only with a lightning flash, but also with a machine spark, or even with an ordinary flame. It is merely necessary that the plate should be exposed to the action of a certain amount of light after it has received the impression and before development."

At the present time Mr. Clayden's explanation may be looked upon as the most reasonable working hypothesis for future use. There is one crucial test which can be tried, which would settle once and for all its value. Unfortunately, so far as I am aware, this test has not yet been made, and I propose (and I hope others will as well) under the next suitable conditions to make the attempt. It is simply this. Take two cameras, say A and B, and orient them both in the same direction towards the point where the same flashes will come in both fields of view. Expose A for say fifteen minutes to record all the flashes that occur during that interval (some of these on development should be *bright*, some *dark*). Expose B for one flash only, preferably the first bright one which occurs during the exposure of A; this should develop *bright*. Compare the same flash on both negatives; that in A should be dark, that in B bright. If this be not the case, then I think the hypothesis breaks down. Perhaps this experiment may not be so easy to perform as it at first appears, for the difficulty lies in being able to catch one strong flash without exposing the plate to any light from other flashes which illuminate the sky, but are not in the field of view themselves. Several attempts by numerous observers would probably give us the information required.

With the object of firstly contributing data towards the interpretation of this curious and interesting phenomenon as recorded by the sensitive film, I give here some illustrations from absolutely untouched negatives of lightning flashes. All these reproductions are reduced about one-third.

FIG. 1.—Lightning flashes taken during a thunderstorm at Göttingen, Germany, in 1893.

I may perhaps preface my descriptions of the photographs by the remark that, having always taken a great interest in procuring lightning flashes by the aid of the camera, I have never, until this year, been fortunate enough in securing records of dark flashes. I have always previously exposed my plates or films for periods of fifteen minutes or more, depending on the strength and nearness of the storm. This fact at first suggested to me the idea that dark flashes might after all be real, but restricted to certain kinds of storms, the special peculiarities of which I cannot state.

FIG. 2.—Showing dark (A and B) and bright (C and D) flashes photographed at Westgate-on-Sea on August 5, 1899.

Fig. 1 is a type of several negatives I have secured previous to this year, and although the exposure was twenty-five minutes in length, an examination of the negative shows absolutely no trace of any *dark* flash. The photograph, which was taken at Göttingen in North Germany, is interesting on account of the fine flash (A) which is traversing the air in a nearly horizontal direction and without any branches or ramifications. In the right-

hand corner will be noticed numerous flashes from clouds a great distance away.

I will now describe three of the four photographs I secured during the storm that passed over Westgate-on-Sea, Thanet, during the night of August 5 of this year (see letter, NATURE, vol. lx. p. 391); all four show


FIG. —Showing bright (B and D) and dark (A and C) flashes photographed at Westgate-on-Sea, on August 5, 1899.

dark as well as bright flashes. The camera employed was one of those excellent and handy little 5 × 4 day-light folding Kodaks, and the exposure in each case was fifteen minutes. The storm, I may add, passed roughly from S.E. towards N.W., and my camera was placed on a window-sill facing due north.

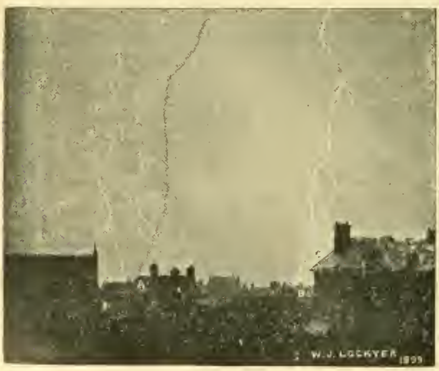


FIG. 4.—Showing bright (B and C) and dark (A) flashes photographed at Westgate-on-Sea, on August 5, 1899.

Fig. 2, showing the north-western sky, displays several flashes, the most prominent of which are C and D bright and A and B dark. The bright flashes have no ramifications, while the dark distinct flash A has several dark. It may be that B is only a large ramification of A, but it is difficult to say.

Fig. 3. The northern sky as here shown displays four prominent flashes, A and C dark and B and D bright. B, as will be noticed, appears to take a very circuitous path, which resembles very closely that illustrated in a previous number of NATURE (vol. xlii. p. 152), and which was a reproduction from a photograph taken on June 6, 1889, by Mr. Rose at Cambridge.

The last, and, I think, absolutely unique photograph of

FIG. —Enlargement of dark flash A in Fig. 4.

a dark flash, is illustrated in Fig. 4. The negative was exposed when the storm was perhaps just a little north of my position (camera pointing due north). The two most prominent flashes are those marked A and B. B is the ordinary bright flash with numerous bright ramifications, while A is also equally, if not more, strong but *dark* with *dark* ramifications. An enlargement of this flash is shown in Fig. 5. Most interesting,

however, is the *reversal*, which extends nearly the whole way up the centre—that is, the dark flash has along its centre a bright core. It is this very photograph which made me cast doubt on the hypothesis suggested by Mr. Clayden, for both a very strong flash can be recorded *very* dark (with a reversal), and also a weak flash (see Fig. 2, B). If the reader refers to an interesting article on "Lightning," by Mr. Jeremy Broome, that appeared in the January number of the *Strand Magazine* in 1897, there will be found a reproduction of a photograph taken at Cambridge by Messrs. Valentine Blanchard and Lunn, showing a *bright* flash with a *dark* reversal down the centre, the exact opposite to the flash recorded above. It may be remarked that a reversal is perfectly distinct from a double flash, many of which have been recorded.

Another flash of interest and peculiarity is that marked C. This flash is quite distinct from B, but unlike all the other bright flashes of about the same intensity, which are clear and sharply defined, this one is occasionally split up along its path into two parts, and the *flash on both sides throughout its whole length is bounded with dark borders.* Both the original negative and a silver print show this peculiarity distinctly, but unfortunately the dark borders are lost in the reproduction. I find that this peculiarity about a flash has been photographed before, but apparently not noticed. If the reader will refer to an old number of *Knowledge* (vol. xviii. p. 224), he will find a reproduction of a lightning flash taken by Mr. George Primavesi at Tooting. This flash is far more intense than that on my negative, and the dark borders are more developed. The main stream is devoid of ramifications: the exposure lasted for only one second.

To sum up, then, the different appearances of the lightning flashes recorded in these photographs, and others of which I possess either photographs or reproductions; we have the following various kinds:—

| Main stream. | Ramifications. | Reversal down centre. | Source of information. |
|---|---|---|---|
| Bright | None | | Fig. 1, A |
| ,, | Bright | | Fig. 4, B |
| ,, | Dark | | NATURE, vol. lx. p. 423 |
| ,, | None | Dark | *Strand Magazine*, Jan. 1897, p. 41 |
| ,, | Bright | Dark | ? |
| ,, | Dark | Dark | ? |
| Dark | None | | Fig. 3, A |
| ,, | Dark | | Fig. 2, A |
| ,, | Bright | | ? |
| ,, | None | Bright | ? |
| ,, | Dark | Bright | Fig. 4, A |
| ,, | Bright | Bright | ? |

The peculiar flash marked C in Fig. 4 I have not inserted in the above table, as it is difficult to decide under which category it should be placed.

Now in attempting to explain the cause of dark lightning I employed Mr. Clayden's idea as a working hypothesis, but I can find no reference to any illustrations of the experiments he carried out. Mr. Shelford Bidwell, however (NATURE, vol. xlii. p. 153), describes and illustrates one out of a series of experiments he made, and this shows dark and bright flashes made artificially, but the flashes are simply dark or bright, with no other peculiarities.

Further, in a letter which appeared in a very recent issue of this journal, Mr. F. H. Glew mentions that he also has made several experiments with regard to the Clayden effect. The illustration which accompanies his account of these investigations (the *Photographic Journal*, vol. xxiii. No. 7, p. 179) shows, like Mr. Bidwell's, no more than simple dark and bright flashes. I may here mention that the method described by me further on was not very dissimilar to that employed by Mr. Glew, although I was unaware until quite recently of the publication of his to which reference has just been made.

Now the point most interesting to me was, Could one artificially produce on one plate or film *exact* types of dark and bright flashes as shown in the above illustrations; that is, flashes which are dark with *bright cores* and bright with *dark borders?* No photographs of sparks produced artificially have, so far as I know, displayed any of these peculiarities.

I will simply describe one experiment that I made, with this object in view, in the laboratory of the Solar Physics Observatory, Kensington.

To produce the spark I employed a 10-inch Apps' coil, with a pint jar in circuit, fed by two cells of four volts each, the sparking distance being two inches. The camera was a small 5 × 4 by Herr Winkel of Göttingen, fitted with a Zeiss objective. Although it was made only


FIG. 6.—Showing three series of sparks taken on one plate against a white background. During the passage of the sparks at C, the background was artificially illuminated.

for the use of glass plates, by a simple device Eastman's film could be employed. Films, I may mention, eliminate all chances of halation.

The method of procedure was as follows:—

In a darkened room I first of all made an exposure on a *single* (2-inch) spark against a bright (white cardboard) background. On development this bright flash came out naturally *bright*.

I next inserted a new film and repeated the same experiment, except that I did not remove the film or develop it immediately. Covering up the lens carefully, I moved the poles in a vertical plane so that the next spark should fall on a different part of the film, and made a second exposure on two sparks. Again covering the lens, and moving the poles a little in the same direction, I exposed the film once more to a series of four sparks, *but while I allowed the sparks to pass I illuminated the cardboard background by burning one inch of magnesium ribbon at a distance of two feet.*

It may be mentioned that the poles only appear on the negative in their respective positions when the background is artificially illuminated. Fig 6 shows the results obtained. A is the first spark, B the two sparks after the first movement of the poles, and C the last four flashes when the background was artificially illuminated.

A close examination of the figure shows that, not only do we get types of simple bright flashes, but we obtain dark flashes with bright cores and bright flashes with dark boundaries.

Now A (Fig. 6) is exactly similar in type to the dark flash in Fig. 4, A, while the two bright flashes in C correspond also to the bright flashes in Fig. 6.

The peculiar flash at C (Fig. 4) is an exact counterpart of D in Fig. 5.

This experiment leads me to conclude, therefore, that Mr. Clayden's hypothesis is entirely corroborated, and explains very satisfactorily the types of flashes illustrated in the above reproductions from photographs.

In studying Fig. 4 in the light of these results, we can form a good idea of the order of appearance of the flashes. That marked A was undoubtedly the first to occur (if the plate had been immediately developed, it would have come out bright); then the flash B made its appearance, and, being so intense, illuminated the neighbouring region round A that the image of A on the film was affected chemically. C was probably next in order of occurrence, but, being more distant and therefore fainter, did not have any effect on A or B. C, however, was affected by subsequent flashes, which were not bright enough to illuminate the field to alter the intense bright flash B in any way, but which were capable of adding dark borders to its sides. The above order of appearance is to a great extent corroborated by the apparent distances and intensities of the flashes.

There seems very little doubt now that, by varying the intensities of the sparks and that of the illuminated background, one can produce any combination of bright and dark flashes. A glance again at Fig. 6 will show that the appearance of a flash depends simply on the magnitude and presence or absence of the core. The following table sums up the six chief types of flashes that probably can be obtained: the reader will notice that there is a complete cycle commencing and terminating with a dark flash.

1. Dark flash, no core.
2. ,, ,, small bright core.
3. Dark flash, broad bright core; or, Bright flash, narrow dark borders.
4. Bright flash, *no* dark borders.
5. ,, ,, small dark core. This would represent an ordinary weak reversal.
6. Bright flash, broad dark core; or, Dark flash, narrow bright borders. This would represent an ordinary strong reversal.
7. Dark flash, *no* bright borders; or, same as No. 1 above.

In the above list photographs have *actually* been obtained of all the types of flashes that came under the headings 1–5. I have examined all my *negatives* to search for the type No. 6, with the result that I have not found a representation of this kind of flash.

It may be remarked that the types 1–3 are produced as a direct consequence of the Clayden effect, and should therefore only appear on plates which contain more than one flash. The other types, which depend simply on the intensity of the flash, should be obtained when even only one flash appears on a plate.

We thus see that actual photographs of lightning bear out what we should expect from laboratory experiments, and we must therefore answer in the negative the question asked in the first line of this article.

Dark lightning flashes therefore do not exist in nature, but their appearances on photographs are due to some chemical action which takes place in the gelatine film.

In closing this article I wish to draw attention to the great interest which is attached to this most fascinating subject. Every one who has a camera can help in the elucidation of the several points to be studied, and most probably bring new facts to light. The photography of lightning flashes during the night is an easy subject, for one has simply to turn the camera towards the dark sky, and the lightning does all the exposing itself. Unfortunately it is not every one who is aware of this fact, and I know of two instances of amateurs who exposed plates during the same storm and at the same place where I obtained the above pictures, but they tried to *catch the flashes by using instantaneous shutters*. Whether they obtained any positive results I do not know, but one could make a very fair guess.

If any readers of this article would be willing to exchange interesting unmounted lightning photographs obtained by them for copies of any of the above illustrations from the original negatives, the writer would esteem it a favour. (Address: 16 Penywern Road, South Kensington, S.W.) This request suggests to me that it would be important for the furtherance and development of this subject, if there were some recognised "Central-Stelle" to which copies of all such photographs could be sent. Those studying the subject would not then be so much hampered in searching for references to accounts of original observations and reproductions, if a fairly complete collection of copies from original negatives were made accessible. WILLIAM J. S. LOCKYER.

## NOTES.

PROF. A. GRAY, F.R.S., Professor of Physics in the University College of North Wales, has been appointed to succeed Lord Kelvin in the chair of Natural Philosophy in the University of Glasgow, and will at once commence his new duties.

THE Harveian Oration will be delivered at the Royal College of Physicians, London, on October 18, by Dr. G. Vivian Poore, and the Bradshaw Lecture on November 2, by Dr. A. Foxwell.

MAJOR RONALD ROSS and other members of the Liverpool Malaria Expedition have returned to this country very well satisfied with their labours. On the advice of the expedition the authorities at Sierra Leone decided to use every means to exterminate the malaria-spreading mosquito. Major Ross is of opinion that the white population is not careful enough, and that the houses are badly constructed, and compare unfavourably with the residences of white people in India, which are constructed on plans that give the inhabitants every chance of health, despite the tropical climate. He attaches great importance to this question of the construction and situation of the houses. Dr. Fielding Ould, a member of the expedition, has remained behind to consult with the medical officers on the coast respecting measures to be taken for the extermination of the malarial mosquito in the neighbourhood of the principal towns. During the investigation one member of the expedition, Mr. Austin, suffered from malaria; he became infected through sleeping one night without the protection of mosquito curtains.

DRS. CALMETTE AND SALEMBENI, who were sent out by the Pasteur Institute as a commission to study and combat the plague in Oporto, have returned to Paris more than satisfied, it is said, with the success attending their efforts with the anti-plague serum. Dr. Calmette is of opinion that the Portuguese might easily free themselves from plague if they would rigorously carry out the measures which have been recommended to them, and in particular if they would inoculate all the inhabitants of suspected quarters. This, however, they appear unwilling to do.

ACCORDING to the *Civil and Military Gazette*, Lahore, the Indian Government has under its consideration a somewhat comprehensive scheme for the establishment of research laboratories

in various parts of India, and the appointment of health officers to the charge of them. The present laboratory at Muktesar will, it is understood, be further developed, and the staff increased, the establishment becoming the central research laboratory for India, and health officers will be appointed to the charge of laboratories at Calcutta, Madras, Bombay, Agra and Lahore, the new department of bacteriology being ordinarily manned by officers of the Indian Medical Service.

DR. CARL PETERS has, it is stated by Reuter, left Portuguese territory and crossed into Mashonaland. Part of his expedition has, however, been left in the neighbourhood of the ancient ruins re-discovered by him near the Zambesi. Dr. Peters' intention is reported to be the establishment of a permanent station on the Inyanga Highlands, and to explore from that point the whole of Mashonaland from north to south. The explorer claims to have discovered mica, saltpetre and diamonds in a district practically uninhabited, at an altitude of 8000 feet, and, he believes, easily capable of cultivation. As the rainy season is now setting in Dr. Peters will, after exploring some districts on the Pungwe River, proceed to Beira *en route* for England.

WE regret to have to record the death, at the age of fifty-eight, of Mr. John Donaldson, a partner of the engineering firm of Thornycroft, which took place last week. Mr. Donaldson had much to do with the introduction of fast torpedo boats into the British Navy, and was a great believer in his firm's water-tube boiler. He was a member of the Institution of Civil Engineers, the Institution of Naval Architects and the Institution of Mechanical Engineers.

*Science* announces the death, at the age of eighty-four, of Chief Justice C. P. Daly, who for many years took a deep interest in scientific matters, particularly in the branches of geography and botany. Mr. Daly was for thirty-six years president of the American Geographical Society, and was largely instrumental in founding the Society's extensive library, and in securing the endowment of its new building. He also rendered good service to the Botanical Garden of New York, and was one of its managers.

MONUMENTS in memory of Siemens and Krupp will be unveiled at Charlottenburg on the 19th inst., the occasion being the centenary of the Technical Institute of that town.

IT having been decided by a number of friends and pupils of the late Dr. Friedel to place a bust and enlarged photograph of him in the hall of the Sorbonne, a circular asking for subscriptions has been distributed. The bust will be the work of M. Uitain, who executed that of Schutzenberger, and is estimated to cost 3000 francs. Subscriptions should be sent to M. Chason, at the Laboratory of Organic Chemistry, Faculty of Science, the Sorbonne.

THE highest observatory in Germany is now completed. It is situated on the Schnee Koppe, the highest summit of the Silesian Mountains, at an elevation of 5216 feet. It will be managed as an institution of the Prussian State.

MR. W. D. HUNTER, special agent of the Division of Entomology, Department of Agriculture, has, says *Science*, returned to Washington, after having studied the Turtle Mountain region in North Dakota and Manitoba, supposed to be a permanent breeding-ground of the Rocky Mountain locust. This, it is reported, he found not to be the case, and he thinks that the probable breeding-ground is the Assiniboine River, north and east of Regina, a region that will be investigated next season.

ACCORDING to *Nature Notes*, a circular has just been issued to all Catholic missionaries by the Sacred Congregation of the Propagation of the Faith, urging them to use such opportunities as the locality of their mission work affords for the collection of natural history specimens, to be given to scientific societies and institutions. The intention, it is asserted, is not only to interest and encourage such missionaries as are keen naturalists, but also to remove the reproach so commonly held that the Church does not look with favour upon science, and especially biological science.

THERE being much difference of opinion as to the kind of ration best adapted for soldiers and sailors in tropical climates, a prize of 100 dollars, or a medal of that value, as the successful competitor may select, has, says the New York correspondent of the *Lancet*, been offered by Dr. Louis L. Seaman for the best thesis on the subject, viz. "The Ideal Ration for an Army in the Tropics." The competition is open to all commissioned medical officers of the U.S. army and navy, regular and volunteer. The prize is offered through the "Military Service Institution of the United States." The executive council of that body has decided that all papers should be submitted by March 1, 1900.

THE joint committee of the Glamorgan County Council and Cardiff Corporation invite applications for the post of bacteriologist and lecturer, to work under the direction of the medical officers of health of the borough and county. Full particulars as to the duties and emoluments of the office will be found in our advertisement columns.

THE American Mathematical Society, which was established on its present basis so recently as 1894, appears to be in a flourishing condition. Its membership is now over three hundred, and at its recent summer meeting, held at Columbus, Ohio, simultaneously with that of the American Association, no fewer than twenty-four papers were read.

IN the address delivered at the opening of the winter session of the Jenner Institute of Preventive Medicine, on Monday last, Dr. Macfadyen gave an account of the institute and its work. In the course of his remarks he said the Anti-toxin Department was engaged in preparing various therapeutic serums, notably the anti-diphtheritic serum, as well as in research in this important field of work. The primary object of the institute was research, but facilities were afforded for post-graduate instruction in preventive medicine and bacteriology. The students had come from all parts of the world, and a considerable amount of original work had been done by those trained in the laboratories. Investigations were at present being made at the institute with reference to the possible cure or prevention of typhoid fever, tuberculosis and other diseases. The diagnosis of infectious diseases was constantly being carried out for the main parishes of London, as well as the investigation of questions affecting the public health on behalf of sanitary authorities. The chemical and State medicine laboratories would find much to do in connection with water, sewage, food, poisons, &c. A notable addition had been made to the resources of the institute in the Hansen Laboratory for the study of the practical application of bacteriology to industrial and technical processes, and the most important results might be anticipated in the future from this branch of investigation.

THE New York *Electrical Review* gives particulars of a recently invented electrical and chemical fire-alarm apparatus, which gives its indications when the atmosphere becomes so vitiated with smoke that it will not support the combustion of a gas flame. In the interior of the apparatus a small gas flame constantly warms a thermostatic bar, the electric circuit through the apparatus being normally open as long as the flame holds out to burn. If the air in the apartment in which the apparatus is installed becomes vitiated with smoke, the little

gas flame goes out, and the thermostatic bar, cooling off, closes the circuit and gives the alarm.

At the International Fishery Congress held at Bergen in 1898, and at that held at Dieppe, an effort was made to start the publication of an "International Review of Fisheries and Fish Culture," which should serve to maintain constant relations between specialists of this branch of science working in different countries. Such efforts were, however, unsuccessful so far as a favourable decision of the Congresses being arrived at was concerned. This being so, and the want of such an organ being considered a very real one, the Russian Imperial Society of Fish Culture and Fisheries has undertaken the publication of such a periodical as has been mentioned, to contain articles in German, French and English. The first number, dated August, has just reached us and contains many interesting contributions, among which may be mentioned "A Short Comparison between the Caspian and the Baltic Seas," "Short Notices of the Fisheries of Sweden," "Fish Culture in the United States," "Contributions to the Study of Fishing Apparatus." The following programme will give an idea as to the scope of the new journal, which has made a very creditable beginning:—New facts pertaining to fish- and oyster-culture (statistics, new methods used in fish-culture, inventions, &c.). New facts and data pertaining to fisheries (statistics, fishing news, inventions, new laws, &c.). Professional education of fishermen and of workmen engaged in the manufacture of preserved fish. Novelties in the manufacture of fish products (new patents, new canneries, &c.). Improvements in the fish-trade and in the methods of carrying fish (fish-markets, cold-storage houses, refrigerator-cars; new duties on imported fish). The work of fishery-societies. Review of scientific investigations connected with fisheries. New books on fish-culture and fishing. Personal notes.

IN a recent number of the Paris *Comptes rendus* (vol. cxxix. p. 417), M. L. Teisserenc de Bort contributes some interesting particulars relating to the temperature of the free air and its variations from observations obtained from ninety unmanned balloons, sent up from his observatory at Trappes since April 1898. The observations have been spread over every month; seven of the ascents exceeded 14,000 metres, twenty-four 13,000 metres, and fifty-three attained a height of 9000 metres. The discussion of the observations exhibits the following general results: (1) The temperature at various heights presents during the course of the year important and greater variations than have been admitted from older series of observations made in manned balloons. The temperature of 0° C. is found at very different altitudes, varying from the level of the ground in winter to above 4000 metres in summer. The isotherm of −25° C. is met with about 3000 metres in winter and above 7000 m. in summer; in September it was observed even above 8000 m. The isotherm of −40° C. was several times found as low as 6000 m., and is generally met with about 9000 m. and even higher towards the end of summer. The temperature of −50° C. has never been recorded below 8000 m.; its greatest altitude was at 12,000 m. (2) There appears to be a marked tendency to an annual variation of temperature even up to 10,000 m., the maximum being about the end of the summer, and the minimum near the end of the winter. The observations given in a table appended to the paper do not show such a rapid variability with height as has been generally supposed; it appears, further, to vary with the type of weather.

IN the *Atti dei Lincei* viii. (2) 4, Dr. D. Lo. Monaco and L. Panichi give a second note on the action of quinine on the parasite of malaria. The most remarkable result is the effect of solutions of strengths lying between certain limits in provoking the exit of the parasites from the red corpuscles, when the parasites are in the second or adult stage. The authors now find that the action of quinine on the endoglobular parasites of spring fever may be thus summed up: (1) in very dilute solutions it excites them; (2) in less dilute solutions the excitement, which reaches its maximum phase in the exit of the parasite from the red corpuscle, is preceded by a brief contraction; (3) in strong or concentrated solutions it paralyses them. There is still some doubt as to the dose of quinine which should be administered in order to effect a cure, and this probably varies in different patients; but it appears that the doses commonly adopted must be regarded as excessive, and that the rational dose suited for curing an attack of spring fever is comprised between half a gramme and a gramme of bisulphate of quinine.

THE *Sitzungsberichte der physikalisch medicinischen Societät* (Erlangen) contains abstracts of several experiments on kathodic rays. The first of these, by Prof. E. Wiedemann and A. Wehnelt, is a simple proof that while kathodic rays are deflected by a magnet, the Goldstein rays are not directly influenced by magnetic force. In the second note the same authors deal with the question of the repulsion of converging kathodic rays, and describe experiments showing that the rays emanating from a hollow kathode cut one another, and that this result is not inconsistent with Weber's experiments. The third note deals with the variations in the potential of discharge in the kathodic dark space, and their independence of ultra-violet or Röntgen rays. Prof. E. Wiedemann contributes a further note on the "simple" kathodic rays of Deslandres. M. Arnold discusses the influence of the luminosity of the anti-kathode on the emission of Röntgen rays; and A. Moffatt gives an interesting note showing that the power of Röntgen rays (*i.e.* their energy divided by the time) is greater than is commonly supposed, and may be about 1 to 10 calories per second.

THE Calabro-Messinese earthquake of November 16, 1894, occupies a prominent place among recent Italian shocks. A Government commission was immediately appointed to study it, but, for various reasons, the complete report has not yet been published. Prof. Riccò, however, has contributed a summary of the seismological section to the Royal Accademia dei Lincei (*Rendiconti*, vol. viii. pp. 3-12, 35-45), and has illustrated it by a map showing the isoseismal lines of the principal shocks of 1894 and 1783. The meizoseismal area of the earthquake of 1894 is situated about twenty miles north-east of Reggio, and the isoseismal lines (which depend, however, on observations from only 170 places) are roughly concentric with this area, but they expand towards the north-west, and are rather crowded together towards the south-east. As a general rule, they follow the boundaries of the great crystalline masses. The total disturbed area (included within the isoseismal 2) is about 44,000 square miles. Nearly a thousand houses were completely destroyed, and more than 44,000 were damaged; about a hundred persons were killed, and a thousand wounded. The earthquake was registered by seismographs at seven Italian observatories, and by the horizontal pendulum at Nicolaiew. A puteometer at Catania indicated a sudden rise of 17 mm. in the well-water, followed by a fall of 14 mm., after which the surface returned nearly to its original position. The mean surface-velocity of the larger vibrations in Italy was almost exactly 2 km. per second; but it varied with the distance, for the hodograph (see NATURE, vol. lii. p. 632) is at first convex to the axis of the distance and afterwards concave. Prof. Riccò remarks that the earthquake of 1894 may be regarded as an after-shock of the great earthquake of 1783, its epicentre being displaced slightly to the south-west; but its intensity was much less, for the meizoseismal area (that bounded by the isoseismal 10) is only one-sixth of that of the earthquake of 1783.

THE department of vertebrate palæontology of the American Museum of Natural History reports that in 1898 the second expedition for Dinosaurs was sent out to Wyoming in charge of Dr. J. L. Wortman, with a party of four. Deposits of Dinosaur bones very favourably situated were found. In all some 60,000 pounds of fossils were secured. This splendid collection reached the museum entirely uninjured, and one-third of it has already been worked out. The fore and hind limbs of these monster reptiles will furnish subjects of great interest for the public. The exhibition hall has been enriched by the skeletons of two great Dinosaurs. A second party, under the direction of Dr. W. D. Matthew, was at work in 1898 in the fossil beds of north-western Kansas and south-western Nebraska. The Bad Lands of north-eastern Colorado were also found to be a rich collecting-ground. Skulls and parts of skeletons were secured, filling many important gaps in the Museum collection. Portions of skeletons and skulls of fossil camels were found, among which is included a gigantic one of the size and proportions of the giraffe. The party also acquired a large amount of other material. It is a little surprising to notice that, though the museum is doing so much to promote educational and scientific advancement in New York, the income in 1898 was insufficient to meet current expenses.

THE monograph, "The Later Extinct Floras of the United States," left unfinisbed by the death of Prof. Newberry, is to be completed by Dr. Arthur Hollick.

THE Essex Technical Instruction Committee have issued, through the County Technical Laboratories, Chelmsford, a report, compiled by Mr. T. S. Dymond, of a visit paid to Holland by Essex agriculturists in May and June of the present year. The report is interesting reading, and gives a brief outline of the more prominent features of Dutch farming. A perusal of the pamphlet will supply English agriculturists with a few hints which in some cases might with advantage be acted upon in this country.

THE report of the Connecticut Agricultural Experiment Station for 1898 has just been published, and is full of valuable matter. Several of the reports contained in the volume should be of interest and service, not only to inhabitants of the State of Connecticut, but to many others.

A SERIES of illustrated articles on "Radiography," by Mr. James Quick, is begun in the October number of *Science Gossip*. The same issue also contains the continuation of articles on "British Freshwater Mites" and "Butterflies of the Palæarctic Region," and numerous other contributions of popular science.

THE Royal Technical Institute, Salford, has issued its calendar for the session 1899-1900. The list of classes is a large one, and, judging from the illustrations of laboratories, workshops, &c., given, the institute is equipped in a very efficient manner.

THE additions to the Zoological Society's Gardens during the past week include a Smooth-headed Capuchin (*Cebus monachus*) from South-east Brazil, presented by Mr. M. P. Peeker; a Chopi Starling (*Aphobus chopi*) from Brazil, presented by Mr. W. R. Routledge; two Orange-flanked Parrakeets (*Brotogerys pyrrhopterus*) from Western Ecuador, presented by Mr. W. H. St. Quintin; three Palm Squirrels (*Sciurus palmarum*) from India, presented by Mrs. M. E. Tracy; a Brown Capuchin (*Cebus fatuellus*) from Guiana, a Guinea Baboon (*Cynocephalus sphinx*) from Africa, a Striped Snake (*Tropidonotus ordinatus sirtalis*) from North America, three Common Snakes (*Tropidonotus natrix*), a Four-lined Snake (*Coluber quatuorlineatus*), a Tessellated Snake (*Tropidonotus tessellatus*), a Smooth Snake (*Coronella austriaca*), a Glass Snake (*Ophiosaurus apus*), an Eyed Lizard (*Lacerta ocellata*), six Slowworms (*Anguis fragilis*), European, deposited; two Baillon's Aracaris (*Andigena baillonî*) from Brazil, a White-browed Amazon (*Chrysotis albifrons*) from Honduras, twelve Dwarf Chameleons (*Chamaeleon pumilus*) from South Africa, purchased; a Wapiti Deer (*Cervus canadensis*), an Axis Deer (*Cervus axis*), born in the Gardens.

## OUR ASTRONOMICAL COLUMN.

COMET GIACOBINI (1899 E).—We have received the following elements and ephemeris (calculated by Herr J. Moller) from the Centralstelle at Kiel.

*Elements.*

T = 1899 Aug. 26·707. Berlin Mean Time.

$$\left.\begin{array}{r} \omega = 358^\circ\ 46'\cdot1 \\ \Omega = 273\ \ 26\cdot9 \\ i = 79\ \ 53\cdot5 \end{array}\right\} 1899\cdot0$$

$$\log q = 0\cdot23796$$

*Ephemeris for 12h. Berlin Mean Time.*

| 1899. | R.A. h. m. s. | Decl. | Br. |
|---|---|---|---|
| Oct. 5 | ... 16 36 59 | ... −3 18′·7 | ... 0·93 |
| 7 | ... 39 50 | ... 2 41·4 | |
| 9 | ... 42 42 | ... 2 5·1 | ... 0·86 |
| 11 | ... 45 34 | ... 1 29·5 | |
| 13 | ... 48 27 | ... 0 54·6 | ... 0·81 |
| 15 | ... 51 20 | ... −0 20·3 | |
| 17 | ... 54 14 | ... +0 13·3 | ... 0·76 |
| 19 | ... 16 57 8 | ... +0 46·4 | |

HOLMES' COMET (1899 *d*).—M. H. J. Zwiers gives in *Ast. Nach.* (Bd. 150, No. 3595) an extended ephemeris of this comet, in the hope that it may still be observed by any one having the necessary optical power, and thus permit of a more exact determination of this orbit.

| 1899. | R.A. h. m. s. | Decl. ° ′ ″ | Br. $(r)^{-2}$ | Br. $(r\Delta)^{-2}$ |
|---|---|---|---|---|
| Oct. 12 | 2 59 45·75 | +48 10 16·1 | | |
| 13 | 58 53·29 | 16 57·5 | | |
| 14 | 57 58·94 | 23 18·9 | | |
| 15 | 57 2·77 | 29 19·7 | 0·1647 | 0·05900 |
| 16 | 56 4·85 | 34 59·8 | | |
| 17 | 55 5·26 | 40 18·7 | | |
| 18 | 54 4·07 | 45 16·1 | | |
| 19 | 2 53 1·35 | +48 49 51·7 | | |

THE ROTATION OF THE SUN.—In a publication issued from the Lund Observatory, Herr C. A. Schultz Steinheil gives the results of his complete discussion of Dunér's spectroscopic determinations of the sun's rotation, extending over the period June 3, 1887–May 18, 1889.

Taking Dunér's spectroscopic values for different positions round the limb and the centre, these are reduced to heliographic coordinates by a table of declination corrections supplied to the author by M. Dunér, and so furnish over 600 equations of condition, which when grouped according to latitude are brought down to 22. Solving these by the method of least squares, the final result appears as

$$x = 2\cdot054 \quad \pm 0\cdot0042$$
$$i = +18^\circ\cdot12 \pm 0\cdot25$$
$$\Omega = +28^\circ\cdot00 \pm 0\cdot50$$

This means that the result of the new discussion of Dunér's spectroscopic observations is that the sun rotates so that a point on its equator moves with a uniform velocity of 2·054 kilometres per second round an axis the inclination of which towards the axis of the ecliptic is 18°·12, the longitude of the intersection of the sun's equator with the ecliptic being +28°·00.

The value of the velocity $x = 2\cdot054$ is not the true velocity, but the synodic; we get the true value by adding $2d \sin \omega$, where $d$ is the velocity of the earth in its orbit in kilometres per second, and $\omega$ the semi-diameter of the sun, expressed in angular measures as seen from the earth.

THE POLARIS MULTIPLE STAR.—Prof. W. W. Campbell is reported to have stated in the *New York Times*:—

"The recent observations of Polaris at the Lick Observatory

show that its velocity is variable. It is *approaching* the solar system now (September 12) with a velocity of 8 kilometres per second. This will increase in two days to 14 kilometres, and in the next two days will decrease to its former value of 8 kilometres. This cycle of changes is repeated every *four* days. . . . The orbit is nearly circular, and is comparable in size with the moon's orbit round the earth.

"This centre of gravity, and therefore the binary system, is approaching the solar system at present with a velocity of 11·5 kilometres per second. A few measures of the velocity of Polaris made here (Lick) in 1896 gave its velocity of approach at the rate of 20 kilometres per second. Part of this change since 1896 could be due to a change in position of the orbit of the binary system, but most of it must have been produced by the attraction of a *third* body on the two bodies comprising the '*four-day*' system."

A CORRESPONDENT to the *Scientific American* (September 16) says that Mr. J. A. Brashear has just completed one of the pair of large astronomical camera doublets for the Observatory of the University of Heidelberg. They are next to the largest so far made, being 16 inches clear aperture and 80 inches focal length. Two of these doublets, each consisting of four lenses, are to be made, and are to be used almost exclusively for the photographic discovery of new asteroids. The reason for using two cameras is to provide a check on the possible inaccuracies inseparable from the use of photographic plates, such as false images, &c. The track of an asteroid with a lens of this focus on an 8 × 10 plate is only about one-twentieth of an inch long for an exposure of three hours. As the curves of the lenses have necessarily to be very deep, the casting of the great discs was found to be very troublesome. The fund for the equipment has been provided by Miss Catherine Bruce, of New York City, who was also the donor of the largest photographic doublet (24-inch aperture), to the Harvard College Observatory at Arequipa.

WE learn from the *Evening Standard* that the expedition sent by the Vienna Academy of Science to India to observe the shower of meteoric Leonids during the night of November 14–15, or the following night, has started from Trieste. The leader of the expedition is Herr Director Weiss, of the Vienna Observatory, who is accompanied by Prof. von Hepperger, of the Gratz University, the astronomers, Dr. Hillebrand, Dr. Prey, Herr Rheder, and Dr. Mache. The Indian Government has promised to give the expedition, which will make its observations near Delhi, every possible assistance.

## *THE FREEDOM OF THE CITY OF MANCHESTER.*

ON Friday, October 6, the City of Manchester conferred her freedom on Enrigueta Augustina Rylands, Robert Dukinfield Darbishire, and Richard Copley Christie.

### MRS. RYLANDS.

Mrs. Rylands presented to the city the library, magnificent in its contents and beautiful in its fabric, which she built in memory of her husband, John Rylands, whose name it bears—John Rylands, who as "a Manchester merchant built up from the lowliest beginnings a business of unparalleled magnitude, and left behind him a name for industry that never hasted nor rested, and a probity that knew no shame."

Principal Fairbairn, in his inaugural address, drew a remarkable parallel between Alexandria, whose library was the richest in the world, and Manchester, "cities, whose princes were merchants and whose merchants princes," and, he added, "everything that raises a great provincial and industrial city to metropolitan rank makes for higher order, sweeter life and purer manners." The opening of this great library calls for national jubilation.

The noble fabric, designed by Mr. Basil Champneys, is in the fourteenth century Gothic style, and is possibly the finest building erected in England in this generation. The building is built entirely of Penrith limestone, the exterior being the dark red Barbary stone, and the interior delicately shaded Shawk stone.

The staircase which leads to the main library is surmounted with a beautiful octagonal lantern surrounded by a carved stone gallery. The library proper is set back ten feet from the line of the building in order to secure a sufficient supply of light, and is built on the collegiate plan in a long aisle ending in an apse, the total length being 148 feet.

The building is vaulted and groined throughout in stone, it is divided into eight bays occupied by bookcases, and contains a gallery in which this arrangement is repeated; two large rooms opening from the apse contain the collection of Bibles, and the maps. The whole building is elaborately finished with statues and carving, and the fittings are all in harmony with the general scheme of decoration.

Two beautiful traceried windows, by Mr. Charles Kempe, form a notable addition to the beauties of the building. The library contains the famous Althorp collection, and Mrs. Rylands' private collection, which contains Wycliffe MSS. and Wynkyn de Wordes; the library has been endowed, and will be kept up to date.

### MR. R. D. DARBISHIRE AND MR. R. C. CHRISTIE.

When Sir Joseph Whitworth lay on his deathbed he attempted to complete a scheme for the utilisation of his property. But he could not explain so vast an idea, and, throwing out his hands, exclaimed "I cannot do it now; I must leave it to you, who know what it means!"

And it was to Lady Whitworth, to Mr. Christie and to Mr. Darbishire that he left his great wealth.

Lady Whitworth has followed her husband; Manchester has created the two remaining co-legatees her honorary citizens in recognition of the admirable way they have carried out their trust.

In connection with this trust, the legatees presented the site of the Manchester Technical School, and contributed largely to the School of Art; made many valuable gifts of money to the Owens College for the engineering laboratory, the museum, the college hospital property, and for general purposes; and presented ten acres of valuable land as an athletic ground for the College; finally presented the Whitworth Hall, now in course of erection at a cost of 50,000*l.* Presented and partially endowed the Whitworth Park and Art Gallery; erected a public library and hall at Openshaw (where Sir J. Whitworth and Co.'s works are situated).

In addition to the great personal labours in the wise and generous application of the Whitworth estate, Mr. Christie rendered invaluable service to the College in the times of storm and stress. Mr. Christie occupied in 1854–5 the united Chairs of History, Political Economy, Law and Jurisprudence. He is president of many learned societies, and chairman of numerous public bodies, charities and trusts; he is president of the Cancer Home and Pavilion, an admirable institution which originated in his generosity.

His chief literary production is the masterly biography of Etienne Dolet, the second edition of which has just been published.

The magnificent new library at the Owens College which bears his name was his personal gift, and was erected at a cost of 21,000*l.*

The total sum which passed through the hands of the Whitworth Trustees was 1,250,000*l.*; of that sum, 250,000*l.* was spent in redeeming promises and obligations, and the legatees themselves are responsible for the distribution of 960,000*l.*

W. T. L.

## *VISIT OF THE INSTITUTION OF ELECTRICAL ENGINEERS TO SWITZERLAND, AUGUST 31 TO SEPTEMBER 8.*

CONSERVATIVE principles are no doubt of considerable service to England, but perhaps least so when applied to the problems of industry. It is a curious and possibly significant fact that as an electrical power England occupies a very insignificant position, and this in spite of the circumstance that the foundations of the industry were to a great extent laid by English engineers. Some years ago a very authoritative statement was made that in so far as ships of war are concerned our best policy is to watch the experiments of foreign nations and to profit by them, rather than make experiments for ourselves; and it is not uncommon to hear similar remarks with regard to the industrial use of electrical appliances. Unhappily we seem to have forgotten the immense advantages which have accrued to us from our pioneering of the railway industry. No doubt in the early days many mistakes were made and much

money was spent in railway experimenting, which foreign countries were afterwards saved; but meanwhile the railway industry had become established in England, and other countries were for many years practically compelled to purchase their railway equipments in England. It seems to the writer of this article that the position formerly occupied by England in railway matters has been taken by America in respect of electric traction, and by Switzerland in regard to the industry of the distribution of electric power. We now certainly profit by American pioneering in electric lighting and tramway work—but we do not get their experience for nothing, for meanwhile their manufacturing industries have become established, and America takes tithe of us when we become her customers. In Switzerland the absence of coal and the presence of an industrious and highly educated population has no doubt co-operated to bring about the wonderful progress which has been made in developing water powers electrically, and in establishing the corresponding industry of the manufacture of electrical appliances. It was on all accounts a happy inspiration for the Institution of Electrical Engineers to visit Switzerland, and for its members to become personally acquainted with the great electrical works of that country; it is only to be regretted that the remainder of the British public did not accompany the members.

Of course we had long understood that the Swiss had done great things electrically, but a visit was necessary to enable us to form an adequate idea of the industrial revolution which has been effected, and whose importance it is impossible to overestimate. It is also impossible to overestimate the kindly hospitality which was extended to the Institution by the great Swiss manufacturing firms, and indeed by the whole electrical fraternity of Switzerland. We were received everywhere with open arms, works were not only thrown open to our inspection, but every effort was made to explain everything that required explanation, and we were made to feel that not only were we guests, but welcome guests. The following brief account is not intended to be a technical description of our visit, for which the electrical journals may be consulted (an excellent account has already appeared in *Engineering*), but is rather in the nature of a record of the writer's general impressions.

*September* 1.—About half the party arrived at Bâle in the morning and spent the afternoon in a visit to the Alioth works at Münchenstein. There is a great similarity between these works and those of Brown, Boveri and Co. at Baden; both are new, both are clean, both are worked for the most part by polyphase motors, both of them make excellently designed machinery, mostly of the alternate current three-phase type, and both of them seemed to have as much work on hand as they could carry out. Though a minor matter, the design of the brush holders for continuous current dynamos at Münchenstein met with some attention; they were very neatly made of aluminium on correct dynamical principles.

*September* 2.—The rest of the party having arrived we went to see the great Power Station at Rheinfelden on the right hand bank of the Rhine. This station has a capacity of twenty turbines of 840 horse power each, the power being supplied by the water of the Rhine with a fall of from three to five metres. To meet variations in the level of the river, the turbines are constructed in a rather peculiar manner, and in fact consist of two turbines on one shaft. The turbine shafts are supported on an oil film, pumped in below a flange; the same high pressure oil being also employed to work the differential governing gear, which it appeared to do very well indeed. However, the load on the dynamos at Rheinfelden is pretty steady, but we found at some other stations that regulation was performed by hand, especially when the power was used for railway or tramway purposes. Some of the power is used for lighting and motors in the villages round about Rheinfelden, and up to a considerable distance away, the three-phase system being employed at a line pressure of 6800 volts. The bulk of the power, however, is used for chemical works on the spot, viz., aluminium, soda and bleach, and carbide, but we were not allowed to see any of these works. The power is a good deal cheaper than at Niagara, and the whole installation gave one the idea that it had "come to stay," the hydraulic works being very solid and the power house roomy and convenient and well kept, though no doubt it had suffered an extra clean up.

The party was entertained at lunch by the directors of the Rheinfelden works; and Herr Rathenau came from Berlin to welcome us, and give us an invitation to visit Berlin next year, an invitation which it is to be hoped the Institution will accept; in any case, Herr Rathenau deserves our best thanks.

In the afternoon we went on by train to the works of Brown, Boveri and Co. at Baden (Switzerland). The works are fairly large, 1300 men and a staff of 170 being employed, and are as much as possible under one roof. Here we saw much the same kind of work that we had seen at the Alioth works, but on a much larger scale. The most interesting exhibit was undoubtedly Mr. C. E. L. Brown himself, who took great pains to ensure our seeing as much as possible in the time at our disposal. The bulk of the work appears to be the construction of three-phase generators and motors of the ordinary type. The large generators were mounted very conveniently with the fixed portion (armature) on trunnions so that it could be turned round for the convenient execution of repairs. The tools were very modern, but there was not nearly so much repeat work being done as the writer at least had expected: nor was there any show of automatic machines. In fact the works were more like an English than an American works, though on a larger scale and newer than any similar works in England.

*September* 4.—The party being now at Zürich, expeditions were made to the Zürich central station, the works of the Oerlikon Company, the gas engine power house of the Zürich-Oerlikon-Seebach tramway, and the works of Messrs. Escher, Wyss and Co.

*The Central Power Station.*—The whole of the water of the river Limmat, which drains the Lake of Zürich, is, or can be, turned through the turbines of the power station, the general construction being very similar to that at Rheinfelden. A good deal of the power is used for pumping water, the excess water being used in high pressure turbines for electric generation.

The Oerlikon works are very like the works at Baden, but are much older, and the generators on the three-phase principle appeared to be chiefly of the inductor type. The design of the three-phase motors appears to depend very much on the size, the small ones having simple short circuited squirrel-cage rotors, while the larger ones have a regular winding, coupled up star fashion, and arranged for the introduction or removal of resistance by pulling or pressing a rod passing up the rotor shaft. We saw a nearly-finished locomotive for the Jungfrau railway, the motors being three-phase and provided with enormous rheostats for varying the speed and absorbing power when the cars run down hill. Who would have thought twenty years ago that the Arago disc contained such potentialities? The steel castings in this works were good throughout.

The works of Escher, Wyss and Co. do not demand any special note in so far as arrangement, &c., is concerned; but the firm seems thoroughly to understand the art of turbine making, as it should do, seeing that most of the turbines in the country appear to have been made at their works. Special pains were taken here to show us everything that was to be seen, and we had an unrivalled opportunity of inspecting the details of turbine construction.

*Dowson Gas Central Station of the Zürich Oerlikon Street Railway at Oerlikon.*—It was rather a surprise to us to find the street railway driven by Dowson Gas in a land reputed to be covered with water powers. The writer must admit to feeling a certain amount of satisfaction at the idea that the water powers were getting exhausted in the neighbourhood of Zürich before British Industry had become a thing of the past. The truth is that there will be no more cheap power for Zürich until some one or other of the numerous schemes for converting valleys into lakes is actually accomplished and very likely not even then. With regard to the Dowson plant itself, there was nothing very striking about it. The engines were not particularly large, but they appeared well made and particularly well water-jacketed. Little or no information could be obtained of interest to Gas Engine people; but economy of coal must be a great consideration when it costs 32 francs per 1000 kilos.

At the Selnau Transformer Station we had an opportunity of seeing how high-tension three-phase currents are used for transmitting power to a sub-station at which continuous current at 500 volts is generated for driving tramway motors. One of the most interesting things about this sub-station was the switches used for turning on the three-phase current, and so starting the continuous current generators to which the three-phase motors are directly coupled. As is, of course, well known, it is in general necessary that resistance should be inserted in the rotor circuit of a three-phase motor in order to enable it to start under any sort of a load. At the Selnau sub-station the switch

board was placed above a kind of stone cellar into which the high pressure leads were conducted, the pressure being 2000 volts. By moving the levers on the switch board the current could be switched on and resistance gradually removed from the star winding in the rotor circuits, so that by the time these had attained their proper speed, all the additional resistance had been cut out. We saw the operation of starting successfully performed.

A number of diagrams had been prepared to illustrate to us the essential characteristics of the apparatus. One of these curves seemed to show that the efficiency of the three-phase motors remained within a very small percentage of the same value, the load increasing from 40 per cent. to its full value, a fact which seems to illustrate the great advantage which may be and is obtained by using these motors on variable loads.

*Visit to Schaffhausen and Neuhausen.*—One is, of course, always pleased to see Schaffhausen on its own account, but there did not seem any particular electrical reason for visiting it. There is the usual central station, power being taken from the Rhine with a fall of from 4 to 5 metres. A little higher up the river there is another similar but older station, the tail race of which is built under the head race of the lower station. One of the turbines was governed by a device which looked about as simple as the machinery employed in cotton spinning, but it seemed to act all the same, though not better than the simpler devices employed by Escher, Wyss and Co. Some of the electric power is used for driving the machinery of a worsted spinning mill and twine works which were visited by several members of the party. Some of the water of the Rhine is deflected, one might almost say stolen, from above the falls at Neuhausen to work a plant most artistically situated just opposite the castle. There is no question but that the appearance of the falls has suffered by the water so deflected, and it is understood that local vested interest in the appearance of the falls is likely to prove too strong for those who desire to utilise their power.

Part of the afternoon was spent in a visit to the works of Messrs. Sulzer Bros. at Winterthur, so well known to engineers as the birthplace of economical engines. We saw several of the engines whose economic performances have secured the admiration of the engineering world. They are of the compound, tandem type, with modified Corliss valve gear, both cylinders being steam jacketed, and heavily lagged with a non-conducting compound. Outside all is a coating of planished steel, which gives the engine a remarkably fine appearance. It appears that there is some evidence that these engines have on occasion developed one I.H.P. on as little as six kilos of steam.

On Wednesday, September 6, a meeting of the Institution of Electrical Engineers was held in the great hall of the Polytechnikum, to hear a paper by Prof. Amsler on the water power at Schaffhausen. Dr. Amsler was not present himself, his paper being read by the secretary, and afterwards discussed indiscriminately by the English and Swiss engineers present. It is not to be inferred from this that they necessarily understood one another; in fact, the writer was rather surprised to find that the linguistic powers of Swiss engineers do not appear to be appreciably greater than those of their English *confrères*.

It is usual to see the Polytechnikum of Zürich held up for our admiration as representing all that is best in technical education. If magnificence of building, opulence in apparatus and luxury of appointment constitutes a successful Polytechnik, then there is no doubt that quite apart from its staff the Zurich institution deserves the position which it apparently commands. The writer cannot help saying that he did not see a single piece of apparatus which he had not seen thousands of times before, that nearly all the apparatus in the Physical Laboratory appeared to him to be clumsy and old-fashioned in design, and that he saw no evidence of anything except an immense amount of what may perhaps be suitably described as second-class teaching of the "fife and drum" order. With regard to the Chemical Laboratory, the appliances were magnificent; but there again, so far as the actual laboratories were concerned, there was not very much of interest, or if there was we did not see it. The basement of the chemical building was taken up by the most magnificent appliances for drawing in fresh air, either through a stream of water in summer time, or over a heated surface in winter, the whole of the air supply of the building being treated in this manner. So far as the writer could judge, the electro technic department appeared to be the most interesting part of the Polytechnikum, and there was no lack of machinery of all kinds of the latest type. It is understood that the Swiss electrical manufactories make great use of the facilities for testing afforded by the electro technic department of the Polytechnikum. It is fair to add that we were rather hurried in our visit; neither the writer nor any one else saw the whole of the departments; and it was the middle of vacation time, when the busiest chemical laboratory looks like a desert.

Thursday, September 7, was practically occupied by a cheap trip to Engelberg, except that it was not particularly cheap. The greater number of the members visited the Stansstad-Engelberg Railway, and for the first time the majority were able to see how a railway may be driven by means of three-phase motors. The starting and stopping of these machines apparently goes on in the smoothest way, and when the cars are running downhill the motors work as generators and pump power back to the generating station, where it is absorbed by resistances. A still better illustration of traction on the three-phase system was afforded by the visit on the last day of the meeting to the Kander power station, near Spiess, and then to the Burgdorf-Thun Railway. In fact, there was a tolerable consensus of opinion that this was the most important day of the tour. The Kander station is not large, but is equipped in the most modern manner by Brown, Boveri and Co. The water of the Kander at Spiezwyler, with an effective head of about 69 metres, is carried in an iron pipe down to the turbine house, where it operates turbines of about 900 horse-power working upon three-phase alternate current generators working at 4000 volts "composed" pressure and 40 cycles per second. This current is partially used for distribution in the neighbourhood; it is partly raised to 16,000 volts, and transmitted to Berne, Burgdorf and Munsingen, where it is re-transformed and used for general purposes. In addition to this, a large part of the power is transmitted at 16,000 volts, and distributed by means of transformer stations along the course of the Burgdorf-Thun Railway at a pressure of 750 volts. Now an electric railway, as everybody knows, takes its power in a very irregular manner, so that the engineers of the Kander station have had to face the difficulty of regulating a load part of which is practically constant and part of which is exceedingly variable. Some, if not all, of the generators are run in parallel, which means that all of them run strictly in synchronism; consequently, if a load varies, the water-supply must be varied to each turbine at the same time and in the same manner. This was being accomplished by the apparently primitive device of having a man on the stop-valve of each turbine. The writer does not feel that he is entitled to pass an opinion on this practice; but on mentioning what he had seen to M. R. Thury, of Geneva, who has had immense experience of hydraulic electric stations, that engineer expressed himself as confident that it is quite possible to regulate even such a variable load as that of the Kander automatically. The writer was informed that there was an accident to the water pipes at the Kander station not very long ago which upset the regulating devices. The pressure at which the current is generated was regulated by two men at the switch board, who constantly varied the exciting current of the exciters of the generators, which was itself furnished by an independent dynamo which was the subject of regulation. In a station of this kind the difficulty of regulation is no doubt affected by the fact that any variation in the water supplied to the turbines necessarily alters the pressure under which the water is delivered. The switch board was a fine complicated affair on a base of white marble, and some of the fittings appeared to be from America.

*Burgdorf-Thun Railway.*—This railway, 40 kilometres long, is not distinguished in any way from an ordinary railway except that it is being worked electrically by power transmitted from the Kander station. The rolling stock consists of ordinary carriages hauled by electric locomotives, each of which carries two asynchronous 300-horse power motors. The motors are connected with the axles through the intermediary of gearing which we were informed can be adjusted to run at either of two speeds, intermediate regulation being obtained by varying the existence of the rotor windings. Immense rheostats are required for motors of this kind, and are carried to a large extent on the top of the locomotive, so that it has a very strange appearance. Two trolley wires are used, the third one being of course the rails, and into this three-wire system current is fed at intervals by fourteen transformer stations. There is nothing of the tramway about this road. It forms part of the permanent railway system of Switzerland, and runs under much the same conditions as if the trains were hauled by steam locomotives.

The average speed is about 18 kilometres per hour with a train of fifty-five tons. Besides the locomotives, automobile carriages equipped up to 240-horse power are provided for the greater part of the passenger traffic, and these trains run at 36 kilometres per hour. Nothing could have been smoother or more satisfactory than the way in which the train (hauled in this case by one locomotive) was stopped and started, and it got up its speed with satisfactory quickness. It may be safely predicted that though this is the first railway of the type (as distinguished from a tramway) it will not be the last, for the transmission of current at 16,000 volts does not demand wires of more than two millimetres diameter for the distances mentioned. No difficulty seems to be experienced in insulation. Ordinary insulators of the double petticoat type without oil are employed, and no special precautions are taken with regard to the posts on which these wires are supported except to inscribe upon them a genial warning as to the fate likely to befall anybody meddling with them.

The railway up the Jungfrau is also a very interesting work, and an excellent day was spent in a visit to it. It goes up to the Rothstock a long way above the Wengern Alp, and there it ends at present in a tunnel. It happened that while some of the party were standing close to the locomotive in the tunnel the line was struck by lightning, the fuses blown in the power station, and the automatic break on the locomotive instantly went into action, though the train was at rest. From the electrical point of view, there was not much to be seen on the Jungfrau Railway, but we had splendid weather, and regarded the trip as a day's holiday.

On the whole we may, perhaps, say that we saw more, but not better, electrical work than can be done in England. We saw that Swiss engineers have the courage of their convictions, and have done more in railway work than most of us had ever dreamed of; and we saw that, as regards the carbide and similar industries, we cannot hope to compete in England till we can get at something cheaper than steam power. On the other hand, English industries in general cannot be regarded as threatened by Swiss enterprise; and Switzerland itself, regarded as a manufacturing country, requires (as Mr. Raworth remarked) to be rolled and to have its lakes filled up.

Richard Threlfall.

## *THE BRITISH ASSOCIATION.*

### SECTION K.

#### BOTANY.

Opening Address by Sir George King, K.C.I.E., LL.D., F.R.S., President of the Section.

*A Sketch of the History of Indian Botany.*

The earliest references in literature to Indian plants are, of course, those which occur in the Sanskrit classics. These are, however, for the most part vague and obscure. The interest which these references have, great as it may be, is not scientific, and they may therefore be omitted from consideration on the present occasion. The Portuguese, who were the first Europeans to appear in India as conquerors and settlers, did practically nothing in the way of describing the plants of their Eastern possessions. And the first contribution to the knowledge of the botany of what is now British India was made by the Dutch in the shape of the "Hortus Malabaricus," which was undertaken at the instance of Van Rheede, Governor of the territory of Malabar, which during the latter half of the seventeenth century had become a possession of Holland. This book, which is in twelve folio volumes and is illustrated by 794 plates, was published at Amsterdam between the years 1686 and 1703, under the editorship of the distinguished botanist Commelyn. Van Rheede was himself only a botanical amateur, but he had a great love of plants and most enlightened ideas as to the value of a correct and scientific knowledge of them. The "Hortus Malabaricus" was based on specimens collected by Brahmins, on drawings of many of the species made by Mathæus, a Carmelite missionary at Cochin, and on descriptions originally drawn up in the vernacular language of Malabar, which were afterwards translated into Portuguese by Corneiro, a Portuguese official in Cochin, and from that language finally done into Latin by Van Douet. The whole of these operations were carried on under the general superintendence of Casearius, a missionary at Cochin. Of this most interesting work the plates are the best part; in fact, some of these are so good that there is no difficulty in identifying them with the species which they are intended to represent. The next important contribution to the botanical literature of Tropical Asia deals rather with the plants of Dutch than of British India. It was the work of George Everhard Rumph (a native of Hanover), a physician and merchant, who for some time was Dutch Consul at Amboina. The materials for this book were collected mainly by Rumphius himself, and the Latin descriptions and the drawings (of which there are over one thousand) were his own work. The book was printed in 1690, but it remained unpublished during the author's lifetime. Rumph died at Amboina in 1706, and his manuscript, after lying for thirty years in the hands of the Dutch East India Company, was rescued from oblivion by Prof. John Burman, of Amsterdam (commonly known as the elder Burman), and was published under the title of "Herbarium Amboinense," in seven folio volumes, between the years 1741 and 1755. The illustrations of this work cover over a thousand species, but they are printed on 696 plates. These illustrations are as much inferior to those of Van Rheede's book as the descriptions are superior to those of the latter The works of Plukenet, published in London between 1696 and 1705, in quarto, contain figures of a number of Indian plants which, although small in size, are generally good portraits, and therefore deserve mention in an enumeration of botanical books connected with British India. An account of the plants of Ceylon, under the name "Thesaurus Zeylanicus," was published in 1737 by John Burman (the elder Burman), and in this work many of the plants which are common to that island and to Peninsular India are described. Burman's book was founded on the collections of Paul Hermann, who spent seven years (from 1670 to 1677) exploring the flora of Ceylon at the expense of the Dutch East India Company. The nomenclature of the five books already mentioned is all uninominal.

Hermann's Cingalese collection fell, however, sixty years after the publication of Burman's account of it, into the hands of Linnæus, and that great systematist published in 1747 an account of such of the species as were adequately represented by specimens, under the title "Flora Zeylanica." This Hermann herbarium, consisting of 600 species, may still be consulted at the British Museum, by the Trustees of which institution it was acquired, along with many of the other treasures possessed by Sir Joseph Banks. Linnæus's "Flora Zeylanica" was followed in 1768 by the "Flora Indica" of Nicholas Burman (the younger Burman)—an inferior production, in which about 1500 species are described. The herbarium on which this "Flora Indica" was founded now forms part of the great Herbarium Delessert at Geneva.

The active study of botany on the binominal system of nomenclature invented by Linnæus was initiated in India itself by Koenig, a pupil of that great reformer and systematist. It will be convenient to divide the subsequent history of botanic science in India into two periods, the first extending from Koenig's arrival in India in 1768, to that of Sir Joseph Hooker's arrival in 1849; and the second from the latter date to the present day.

The pioneer John Gerard Koenig was a native of the Baltic province of Courland. He was a correspondent of Linnæus, whose pupil he had formerly been. Koenig went out to the Danish settlement at Tranquebar (150 miles south of Madras) in 1768, and at once began the study of botany with all the fervour of an enthusiasm which he succeeded in imparting to various correspondents who were then settled near him in Southern India. These friends formed themselves into a society under the name of "The United Brothers," the chief object of their union being the promotion of botanical study. Three of these brothers, viz. Heyne, Klein and Rottler, were missionaries located near Tranquebar. Gradually the circle widened, and before the century closed the enthusiasm for botanic research had spread to the younger Presidency of Bengal, and the number of workers had increased to about twelve, among whom may be mentioned Fleming, Hunter, Anderson, Berry, John, Roxburgh, Buchanan (afterwards Buchanan-Hamilton), and Sir William Jones, so well known as an Oriental scholar. At first it was the custom of this brotherhood merely to exchange specimens, but gradually names began to be given, and specimens, both named and unnamed, began to be sent to botanists of established reputation in Europe. Many plants of Indian origin came thus to be described by Retz, Roth, Schrader, Willdenow, Vahl and

Smith. Rottler was the only member of the band who himself published in Europe descriptions of any of the new species of his own collecting, and these appeared in the "Nova Acta Acad. Nat. Curiosorum" of Berlin. A little later Sonnerat and other botanists of the French settlement at Pondicherry sent large collections of plants to Paris, and these were followed at a considerably later date by the collections of Leschenhault. These French collections were described chiefly by Lamarck and Poiret. Hitherto botanical work in India had been more or less desultory, and it was not until the establishment in 1787 of the Botanic Garden at Calcutta that a recognised centre of botanical activity was established in British India. Robert Kyd, the founder of that Garden, was more of a gardener than a botanist. He was, however, a man of much energy and shrewdness. The East India Company was still in 1787 a trading company, and a large part of their most profitable business was derived from the nutmegs and other spices exported from their settlements in Penang, Malacca, Amboina, Sumatra, and other islands of the Malayan Archipelago. The Company were also in those days the owners of a fine fleet of sailing vessels, and the teak of which these ships were built had to be obtained from sources outside the Company's possessions. The proposal to found a botanic garden near Calcutta was thus recommended to the Governor of the Company's settlements in Bengal on the ground that, by its means, the cultivation of teak and of the Malayan spices might be introduced into a province near one of the Company's chief Indian centres. Kyd, as a Lieutenant-Colonel of the Company's engineers, and as secretary to the Military Board at Calcutta, occupied a position of considerable influence, and his suggestion evidently fell on no unwilling ears; for the Government of Bengal, with the promptitude to accept and to act on good advice in scientific and semi-scientific matters which has characterised them from the day of Kyd until now, lost no time in taking steps to find a site for the proposed garden. Colonel Kyd's official proposal was dated June 1, 1786, and, in a despatch dated August 2, the Calcutta Government recommended Kyd's proposal to the Court of Directors in London. Posts were slow and infrequent in those days, and the Calcutta Government were impatient. They did not wait for a reply from Leadenhall Street, but in the following July they boldly secured the site recommended by Colonel Kyd. This site covered an area of 300 acres, and the whole of it, with the exception of thirty acres which were subsequently given up to Bishop Middleton for an English college, still continues under cultivation as a botanic garden. Kyd died in 1793, and in the same year his place as superintendent of the garden was taken by Dr. William Roxburgh, a young botanical enthusiast, and one of Koenig's "United Brotherhood." Roxburgh had studied botany in Edinburgh, where he was a favourite pupil of Dr. Hope. Desirous of seeing something of foreign countries, he made several voyages to Madras in ships belonging to the Honourable East India Company. In 1776 he accepted an appointment in the Company's medical establishment, and was posted to the town of Madras, where he very soon made the acquaintance of Koenig. Roxburgh was shortly after transferred to a remote district, a good deal to the north of Madras, then named the Northern Circars. The station of Samulcotta, which formed Roxburgh's headquarters during his sojourn in the Circars, stands on the edge of a hilly region possessing a very interesting flora, and this flora he explored with the greatest ardour; and, as part of the result of his labours, an account of some of the most interesting of its plants was published in London, at the East India Company's expense, in three large folio volumes, under the title, "The Plants of the Coast of Coromandel." This was Roxburgh's earliest publication on a large scale. The first part of this book appeared in 1795, and the last not until 1819, *i.e.* five years after the author's death. The increased facilities afforded to Roxburgh after his transfer to a comparatively well-equipped institution like that at Calcutta induced him at once to begin the preparation of descriptions of all the plants indigenous to British India of which he could procure specimens. And so diligently did he work that, when he was finally driven from India by ill-health in 1813, he left complete and ready for publication the manuscripts of his "Flora Indica" and of his "Hortus Bengalensis" (the latter being an enumeration of the plants in cultivation in the Calcutta garden). He also left admirable coloured drawings (mostly of natural size) of 2533 species of plants indigenous to India. Seldom have twenty years yielded so rich a botanical harvest! Dr. Roxburgh was thus the first botanist who attempted to draw up a systematic account of the plants of India, and his book, which is on the Linnæan system, is the basis of all subsequent works on Indian botany; and until the publication of Sir Joseph Hooker's monumental "Flora of British India," it remained the only single book through which a knowledge of Indian plants could be acquired. Roxburgh was immediately succeeded in the Calcutta garden by Dr. Buchanan-Hamilton, a man of many accomplishments, who had travelled from Nepal in the North to Ava and Mysore in the South, accumulating materials for a gazetteer of the Honourable Company's possessions. Dr. Buchanan was a zoologist as well as a botanist. He had published a valuable account of Mysore, Canara and Malabar, and had collected materials for a work on the Fishes of India; besides having accumulated a large herbarium, part of which may now be consulted at the University of Edinburgh. Prior to his death Buchanan-Hamilton had begun to write a learned commentary on Van Rheede's "Hortus Malabaricus." Many of his Nepalese collections were described in 1825 (a few years before his own death) by Don in his "Prodromus Floræ Nepalensis." Buchanan-Hamilton remained only one year at Calcutta, and in 1815 he was succeeded by Nathaniel Wallich, a native of Copenhagen, who, prior to his appointment to the Calcutta garden, had been attached to the Danish settlement at Serampore, twenty miles higher up the Hooghly. Wallich remained superintendent of the Calcutta garden for thirty years. In 1846 he went to England, and in 1854 he died. During his tenure of office in the Calcutta garden, Wallich organised collecting expeditions to the then little-known regions of Kamaon and Nepal (in the Himalaya), to Oudh, Rohilcund, Sylhet, Tenasserim, Penang, and Singapore. He undertook, in fact, a botanical survey of a large part of the Company's possessions in India. The vast materials thus collected under his own immediate direction, and the various contributions made by others, were taken to London by him in 1828. With these were subsequently incorporated the collections of Russell, Klein, Heyne, Rottler, Buchanan-Hamilton, Roxburgh, and Wight. And by the help of a band of distinguished European botanists, among whom may be named De Candolle, Kunth, Lindley, Meissner, Nees von Esenbeck, Von Martius and Bentham (the latter in a very special manner), this vast mass of material was classified and named specifically. A catalogue of the collection was prepared by Wallich himself (largely aided by Bentham), and sets of the named specimens were distributed to the leading botanical institutions in Europe, every example of each species bearing the same number. No description of the whole collection was ever attempted, but many of the plants belonging to it were subsequently described in various places and at various times. So extensive was the Wallichian distribution that, amongst the names and synonyms of tropical Asiatic plants, no citation is more frequent in botanical books than that of the contraction "Wall. Cat." Besides the naming and distribution of this gigantic collection, Wallich prepared and published, at the expense of the same liberal and enlightened East India Company, his "Plantæ Asiaticæ Rariores," in three folio volumes with 300 coloured plates. He also contributed to an edition of Roxburgh's "Flora Indica," which was begun by the celebrated Dr. Carey of Serampore, descriptions of many plants of his own collecting. But the task of publishing his discoveries in this way proved beyond his powers, as it would have proved beyond those of any one who had only 365 days to his year, and less than a hundred years as his term of life! Carey and Wallich's edition of Roxburgh's "Flora Indica" was brought to an untimely conclusion at the end of the *Pentandria Monogynia* of Linnæus. Wallich also began an illustrated account of the flora of Nepal under the title, "Tentamen Floræ Nepalensis." But this also came to a premature end with the publication of its second part.

During much of the time that Wallich was labouring in Northern India, Robert Wight, a botanist of remarkable sagacity and of boundless energy, was labouring in Southern India, chiefly in parts of the Peninsula different from those in which Koenig and his band had worked. Wight was never liberally supported by the Government of Madras, and it was mostly by his own efforts and from his own resources that his collections were made and that his botanical works were published. The chief of the latter is his "Icones Plantarum." This book consists of figures with descriptions of more than two thousand Indian species. A good many of the plates are indeed copies

from the suite of drawings already referred to as having been made at Calcutta by Dr. Roxburgh. The rest are from drawings made, either by native artists under his personal supervision, or by his own hands. Ample evidence of the extraordinary energy of Dr. Wight is afforded by the facts that, although he had to teach the native artists whom he employed both to draw and to lithograph, the two thousand *Icones* which he published and described were issued during the short period of thirteen years, and that during the whole of this time he performed his official duties as a medical officer.

Besides this *magnum opus*, Wight published his *Spicilegium Nilghirense* in two vols. quarto, with 200 coloured plates. And between 1840 and 1850 he issued in two vols. quarto, with 200 plates, another book named "Illustrations of Indian Botany," the object of which was to give figures and fuller descriptions of some of the chief species described in a systematic book of the highest botanical merit, which he prepared conjointly with Dr. J. Walker-Arnot, Professor of Botany in the University of Glasgow, and which was published under the title "Prodromus Floræ Peninsulæ Indicæ." The "Prodromus" was the first attempt at a flora of any part of India in which the natural system of classification was followed. Owing chiefly to the death of Dr. Walker-Arnot, this work was never completed, and this splendid fragment of a flora of Peninsular India ends with the natural order *Dipsaceae*.

The next great Indian botanist whose labours demand our attention is William Griffith. Born in 1810, sixteen years after Wight, and twenty-four years later than Wallich, Griffith died before either. But the labours even of such devotees to science as were these two are quite eclipsed by those of this most remarkable man. Griffith's botanical career in India was begun in Tenasserim. From thence he made botanical expeditions to the Assam valley, exploring the Mishmi, Khasia and Naga ranges. From the latter he passed by a route never since traversed by a botanist, through the Hookung valley down the Irrawadi to Rangoon. Having been appointed, soon after his arrival in Rangoon, surgeon to the Embassy to Bhotan, he explored part of that country and also part of the neighbouring one of Sikkim. At the conclusion of this exploration he was transferred to the opposite extremity of the Northern frontier, and was posted to the Army of the Indus. After the subjugation of Cabul, he penetrated to Khorassan. Subsequently he visited the portion of the Himalaya of which Simla is now the best-known spot. He then made a run down the Nerbudda valley in Central India, and finally appeared in Malacca as Civil Surgeon of that Settlement. At the latter place he soon died of an abscess of the liver brought on by the hardships he had undergone on his various travels, which were made under conditions most inimical to health, in countries then absolutely unvisited by Europeans. No botanist ever made such extensive explorations, nor himself collected so many species (9000) as Griffith did during the brief thirteen years of his Indian career; none ever made so many field notes or wrote so many descriptions of plants from living specimens. His botanical predecessors and contemporaries were men of ability and devotion. Griffith was a man of genius. He did not confine himself to the study of flowering plants, nor to the study of them from the point of view of their place in any system of classification. He also studied their morphology. The difficult problems in the latter naturally had most attraction for him, and we find him publishing, in the *Linnaean Transactions*, the results of his researches on the ovule in *Santalum*, *Loranthus*, *Viscum*, and *Cycas*. Griffith was also a cryptogamist. He collected, studied, and wrote much on Mosses, Liverworts, *Marsiliaceae*, and Lycopods, and he made hundreds of drawings to illustrate his microscopic observations. Wherever he travelled he made sketches of the most striking features in the scenery. His habit of making notes was inveterate; and his itinerary diaries are full of information, not only on the botany, but also on the zoology, physical geography, geology, meteorology, archæology and agriculture of the countries through which he passed. His manuscripts and drawings, although left in rather a chaotic state, were published after his death under the editorship of Dr. McClelland, at the expense of the enlightened and ever-liberal East India Company. They occupy six volumes in octavo, four in quarto, and one (a "Monograph of Palms") in folio.

Another botanist of much fame, who died prematurely in 1822, after an Indian career of only nine years, was William Jack. In 1814-15, Jack accompanied Ochterlony's army to the Nepal terai. He was transferred in 1818 to the Company's settlement in Sumatra under Sir Stamford Raffles, and during the four years of his residence in Sumatra he contributed to botanical literature descriptions of many new genera and species which were published in his "Malayan Miscellanies." His collections, unfortunately, were for the most part lost by an accident, but those which were saved are now in the Herbarium Delessert in Geneva.

Somewhat similar to Griffith in temperament and versatility was the brilliant Victor Jacquemont, a French botanist who, at the instance of the Paris Natural History Museum, travelled in India for three years from 1829 to 1832. During this period Jacquemont collected largely in the Gangetic plain. He then entered the North-west Himalaya at Mussourie, explored Gharwal and Sirmur, ascended the Sutlej to Kanawer and Piti (at that time unexplored), visited Cashmir, and returning to the plains, crossed Northern Rajputana to Malwa and the Deccan. He finally reached Bombay with the intention of returning to France. But at Bombay he succumbed to disease of the liver, brought on by hard work and exposure. His remains, after having lain in the cemetery there for fifty years, were, with that tender regard for the personality of her famous sons which France has always shown, exhumed in 1881, and conveyed in a French frigate to find a permanent resting-place in the place of Jacquemont's birth. Jacquemont's collections were transmitted to Paris, and his plants were described by Cambessedes and Decaisne, while his non-botanical collections were elaborated by workers in the branches of science to which they respectively appertained, the whole being published in four volumes quarto, at the expense of the French Government.

The roll of eminent botanists who worked in India during the first half of the century closes with the name of Thomas Thomson, who collected plants extensively between 1842 and 1847 in Rohilkund and the Punjab, and again still more extensively during a Government mission to the North-west Himalaya and Tibet which was continued from 1847 to 1849. During this period Dr. Thomson explored Simla, Kanawar, Piti, Cashmir, Ladak, and part of the Karakoram. His collections, which were large and important, were transmitted to the Botanic Garden at Calcutta, and thence in part to Kew. They formed no insignificant part of the materials on which the "Flora Indica" and "Flora of British India" were founded. Dr. Thomson also published an account of his travels—an admirable book, though now jostled out of memory by the quantities of subsequently issued books of Himalayan travel and adventure.

About the year 1820 a second centre of botanical enterprise was established at Seharunpore, in the North-west Provinces. A large old garden near that important town, which had been originally founded by some Mahommedan nobles of the Delhi Court, was taken over by the Honourable Company, and was gradually put upon a scientific basis by Dr. George Govan, who was appointed its first superintendent. Dr. Govan was in 1823 succeeded by Dr. J. Forbes Royle, and he in 1832 by Dr. Hugh Falconer. Dr. Royle made collections in the Jumno-Gangetic plain, in the Lower Gharwal Himalaya, and in Cashmir. He was distinguished in the field of economic rather than in that of systematic botany, his chief contribution to the latter having been a folio volume entitled "Illustrations of the Botany of the Himalaya Mountains." His valuable labours as an economic botanist will be noticed later on. Hugh Falconer was an accomplished palæontologist who devoted but little of his splendid talents to botany. His great contribution to palæontology, the value of which it is almost impossible to over-estimate, consisted of his exploration and classification of the tertiary fossils of the Sewalik range. Falconer was transferred to the Calcutta Garden in 1842. He was succeeded at Seharunpore by Dr. W. Jameson, who explored the botany of Gharwal, Kamaon and Cashmir, but who published nothing botanical, his chief energies having been devoted to the useful work of introducing the cultivation of the China tea plant into British India, and this he did (as will afterwards be mentioned) with triumphant success.

During the first half of the century a considerable amount of excellent botanic work was done in Western India by Graham, Law, Nimmo, Gibson, Stocks and Dalzell, the results of whose labours culminated in the preparation by Graham of a list of the plants of Bombay, which was not, however, published until 1839 (after his death); in the publication by Stocks of various papers on the botany of Scinde; and in the publi-

cation by Dalzell in 1861 of his "Flora of Bombay." It is impossible in a brief review like the present to mention the names of all the workers who, in various parts of the gradually extending Indian Empire, added to our knowledge of its botanical wealth. It must suffice to mention the names of a few of the chief, such as Hardwicke, Madden, Munro, Edgeworth, Lance and Vicary, who collected and observed in Northern India, and who all, except the two last mentioned, also published botanical papers and pamphlets of more or less importance; Jenkins, Masters, Mack, Simons and Oldham, who all collected extensively in Assam; Hofmeister, who accompanied Prince Waldemar of Prussia, and whose collections form the basis of the fine work by Klotsch and Garcke (*Reis. Pr. Wald.*); Norris, Prince, Lobb and Cuming, whose labours were in Penang and Malacca; and last, but not least, Strachey and Winterbottom, whose large and valuable collections, amounting to about 2000 species, were made during 1848 to 1850 in the higher ranges of the Kamaon and Gharwal Himalaya, and in the adjacent parts of Tibet. In referring to the latter classic Herbarium, Sir Joseph Hooker remarks that it is "the most valuable for its size that has ever been distributed from India." General Strachey is the only one who survives of the splendid band of collectors whom I have mentioned. I cannot conclude this brief account of the botanical labours of our first period without mentioning one more book, and that is the "Hortus Calcuttensis" of Voigt. Under the form of a list, this excellent work, published in 1845, contains a great deal of information about the plants growing near Calcutta, either wild or in fields and gardens. It is strong in vernacular names and vegetable economics.

(*To be continued.*)

## *MATHEMATICS AT THE BRITISH ASSOCIATION.*

THE visit of the French Association to Dover necessitated some departures from the usual programme of the British Association week, and the mathematical meeting was held this year on Monday, September 18. Prof. Forsyth, of Cambridge, presided over a well-filled room.

The session opened with the formal communication of two reports of committees: the first, drawn up by Prof. Karl Pearson, and practically forming a continuation of a previous report, contains a set of tables of certain functions connected with the integral

$$G(r, \nu) = \int_0^\pi \sin^r\theta e^{\nu\theta} d\theta,$$

for integral values of $r$ from 1 to 50, and for values of $\nu$ at certain intervals from 0 to 1. These functions are of importance in certain statistical problems.

The second report consists substantially of the new "Canon Arithmeticus" which Lieut.-Colonel Cunningham has prepared; the Association has made a grant for publishing the tables as a separate volume (they cannot well be fitted into the comparatively small page of the B.A. Report), and it is to be hoped that before long they will become generally available for workers in the Theory of Numbers.

The first of the papers was read by Dr. Francis Galton, on "The Median Estimate." Dr. Galton proposes to substitute a scientific method for the very unsatisfactory ways in which the collective opinion of committees and assemblies of various kinds is ascertained, in respect to the most suitable amount of money to be granted for any particular purpose. How is that medium amount to be ascertained which is the fairest compromise between many different opinions? An average value—*i.e.* the arithmetic mean of the different estimates—may greatly mislead, because a single voter is able to produce an effect far beyond his due share by writing down an unreasonably large or unreasonably small sum. Again, few persons know what they want with sufficient clearness to enable them to express it in numerical terms, from which alone an average may be derived; much deeper thought-searching is needed to enable a man to make such a precise affirmation as that "in my opinion the bonus to be given should be 80*l*.," than to enable him to say "I do not think he deserves so much as 100*l*., certainly not more than 100*l*."

Dr. Galton's plan for discovering the medium of the various sums desired by the several voters is to specify any two reasonable amounts A and B, and to find what percentage $a$ of voters think that the sum ought to be less than A, and what percentage $b$ vote for less than B. It may now be assumed that the estimates will be distributed on either side of their (unknown) *median* $m$, with an (unknown) quartile $q$, in approximate accordance with the normal law of frequency of error; and thus (using the table of centiles given in the author's "Natural Inheritance") the required median value can be found.

This was followed by a paper "On a system of invariants for parallel configurations in space," by Prof. Forsyth. The process followed by the author is one in which English mathematicians have always excelled—namely, the deduction of difficult analytical results from simple geometrical considerations. Prof. Forsyth's final formulæ may be regarded as invariantive relations between certain definite integrals: the way in which he finds them is as follows:—

Consider any plane curve; if we suppose a circle of constant size to roll on the curve, its envelope will be another curve, which is said to be *parallel* to the original one. If now L be the length and A the area of a curve, it is found that the quantity $A - \frac{1}{4\pi}L^2$ has the same value for the parallel as for the original curve; in other words,

$$A - \frac{1}{4\pi}L^2$$

is *invariantive* for parallel curves. Similarly in space of three dimensions, the envelope of a sphere of fixed size which rolls on a given surface is another *parallel* surface; and if V be the volume contained by a surface, S its superficial area, and L twice the surface-aggregate of the mean of the curvatures at any point, then it is found that the quantities

$$S - \frac{1}{16\pi}L^2 \text{ and } V - \frac{1}{8\pi}LS + \frac{1}{192\pi^2}L^3$$

are invariantive for all parallel surfaces.

Similar results hold for space of $n$ dimensions. At the end of the paper the expressions obtained are shown to be connected with the ordinary invariant-theory of binary forms.

The next paper, read by Prof. Everett, was concerned with "The Notation of the Calculus of Differences." In conjunction with the ordinary symbol $\Delta$, defined by

$$\Delta y_n = y_{n+1} - y_n,$$

Prof. Everett employs another symbol $\delta$, defined by

$$\delta y_n = y_n - y_{n-1},$$

so that

$$\delta = \Delta/_{1+}\Delta.$$

The use of $\delta$ simplifies some of the well-known formulæ of the calculus of finite differences.

Prof. A. C. Dixon, of Galway, followed, with a paper "On the Partial Differential Equation of the Second Order." Let $z$ be the dependent, and $x$ and $y$ the independent, variables; and with the usual notation, let

$$p = \frac{\partial z}{\partial x}, \quad q = \frac{\partial z}{\partial y}, \quad r = \frac{\partial z^2}{\partial x^2}, \quad s = \frac{\partial z^2}{\partial x \partial y}, \quad t = \frac{\partial z^2}{\partial y^2},$$

and consider the differential equation

$$f(x, y, z, p, q, r, s, t) = 0.$$

This may be supposed solved by using two more relations

$$u = a, \quad v = b,$$

among the quantities $x, y, z, p, q, r, s, t$, to give values of $r, s, t$, which, when substituted in

$$dz = pdx + qdy, \quad dp = rdx + sdy, \quad dq = sdx + tdy,$$

render these three equations integrable. This will not be possible, of course, unless the expressions $u$, $v$, fulfil certain conditions. Prof. Dixon considers the case in which $u$ can be so determined that $v$ is only subjected to one condition, and finds that then $du$ is a linear combination of the differential expressions used in Hamburger's method of solution. If such a function $u$ can be found, the system $f=0$, $u=a$, will have a series of solutions depending on an arbitrary function of one variable, and involving two further arbitrary constants.

The next paper, "On the Fundamental Differential Equations of Geometry," was read by Dr. Irving Stringham, of the University of California. Dr. Stringham derives the analytical formulæ for non-Euclidian Geometry by following a procedure indicated by Feye St. Marie, and later discussed in Killing's "Nicht-Euclidischen Raumformen." Within an infinitesimal domain in non-Euclidian space, the propositions of Euclidian

Geometry may be regarded as true; from this fact can be deduced a group of equations typified by

$$\frac{da}{d\alpha}=\frac{f(b)}{\sin\gamma},\quad \frac{db}{aa}=\cos\gamma,\quad f'(b)=-\frac{d\gamma}{d\alpha},$$

where $a$, $b$, $c$, are the sides of a triangle, and $\alpha$, $\beta$, $\gamma$, the corresponding angles. From these, by appropriate eliminations and transformations, the differential equation

$$\{f(a)\}^2=-\kappa^2[1-\{f'(a)\}^2]$$

can be found for the function $f$. Solving this, we have

$$f(a)=\kappa\sinh\frac{a}{\kappa},$$

and thence can derive the fundamental equations of non-Euclidian measurement.

$$\sinh\frac{a}{\kappa}\Big/\sinh\alpha=\sinh\frac{b}{\kappa}\Big/\sin\beta=\sinh\frac{c}{\kappa}\Big/\sin\gamma.$$

This was followed by the communication of a Report on the Problem of Three Bodies, which Mr. E. T. Whittaker was commissioned to prepare at the Toronto meeting. In a general sketch of the results, Mr. Whittaker explained the transformation which has taken place in dynamical astronomy as a result of the researches of Newcomb, Hill, Lindstedt and Poincaré. Formerly the subject might be said to consist of two departments—the planetary and lunar theories; now the distinction between these was becoming less prominent, as the Problem of Three Bodies was treated in greater generality. Among the advances referred to were Dr. Hill's introduction of periodic orbits as a substitute for Keplerian ellipses in the first approximation to the solution, Newcomb's proof that the problem can be solved by series in which the time occurs only in the arguments of trigonometric functions, Poincaré's theorem that these series are only asymptotic expansions, and Bruns' result that the system possesses no algebraic integrals other than those already known.

A second paper by Prof. Forsyth, "On Singular Solutions of Ordinary Differential Equations," described some properties of the $p$-discriminant and $c$-discriminant of an ordinary differential equation of the first order. The two last papers on the list were "An Application and Interpretation of Infinitesimal Transformations," by Dr. E. O. Lovett, of Princeton University, N.J.; and "On Fermat's Numbers," by Lieut.-Colonel Cunningham. In the absence of their authors the papers were communicated by title, and the session was closed.

Looking at the papers as a whole, they were of just that character which makes the B.A. meeting useful to mathematicians; that is, they related not so much to abstruse continuations of well-known theories as to new and little-known subjects, suggestions of improved notations, reports on the recent progress of different branches of mathematics, and generally all those topics for which discussion at a real meeting is more important than the publication of a paper.

## PHYSICS AT THE BRITISH ASSOCIATION.

THE attendance of physicists at Dover was rather smaller than usual, on account of the occurrence of the Volta Centenary celebrations at Como and the simultaneous meetings of the French Association for the Advancement of Science at Boulogne. Several of those who in past years have been leaders in the discussions of Section A were this year conspicuous by their absence. Nevertheless, the papers read maintained a high standard of excellence, and the reports presented indicate that good work is being done by the committees appointed for scientific research.

The address delivered by Prof. Poynting, as President of the Section, was the subject of many conversations, not only among physicists but with biologists also; the existence of the sharp line which he indicated between the psychical and physical methods and the phenomena to which each is applicable, was acknowledged on all sides. The physicists were divided on the question of the danger of too much hypothesis, and especially on the possibility of the propagation of electromagnetic waves in air being due to the air as much as to the ether. All, however, were agreed in the expression of thanks to the President, proposed by Sir George Stokes and seconded by Sir Norman Lockyer.

In a paper on the spectroscopic examination of contrast phenomena, Mr. G. J. Burch described experiments which lend great support to the Young-Helmholtz theory of colour-vision. If the eye is fatigued by exposure to a very intense red light, such as sunlight filtered through red screens and focussed on the eye, and a spectrum be then looked at, the red is invisible; but the rest of the spectrum, green to violet, appears in its ordinary colours. Red-blindness is therefore not accompanied by green-blindness, as Hering's theory requires. Further experiments on the blue and violet portions of the spectrum have led Mr. Burch to the conclusion that we have separate primary sensations for blue and violet, in addition to those for red and green, making four altogether instead of the three postulated by the Young-Helmholtz theory. The experiments are the more convincing because carried out with spectral colours, thus avoiding all errors due to the impurity of pigment colours. In the discussion on the paper several members took part; Sir George Stokes said experiments led him to believe that lobelia blue is a primary sensation, and Principal Glazebrook suggested that the theory should be tested by colour-matches on a spectrophotometer.

Prof. Callendar gave the preliminary results of a research on the variation of the specific heat of water with temperature, which he commenced in Montreal with Mr. H. T. Barnes, and which is now being continued by the latter. The method of experiment consists in allowing water to flow steadily through a narrow tube along which a platinum wire runs axially; on passing a constant electric current through the wire the water finally acquires a steady temperature-difference between the inlet and outlet of the tube, which is measured by platinum thermometers and automatically recorded. Radiation corrections are reduced to a minimum by surrounding the tube with a vacuum-jacket, and the electrical energy supplied is measured by observing the current and the potential-difference between the ends of the wire in the tube. The results show that the specific heat of water has a minimum value of 0·995 in the neighbourhood of 40° C., it rises to 1·000 as the temperature falls to 10° C., and continues to rise rapidly as the temperature decreases. On increasing the temperature above 40° C. the specific heat rises to 0·997 at 60° C. Further experiments will be made in the neighbourhood of the freezing point and on either side of it.

The committee on electrolysis and electro-chemistry has undertaken the comparison of the variation of electrical conductivity with concentration, and the variation of freezing point with concentration for identical very dilute aqueous solutions of electrolytes. The electrical measurements have been successfully carried out by Mr. W. C. Whetham, but the freezing point determinations, undertaken by Mr. E. H. Griffiths, have been delayed by the discovery of errors arising from the presence of dissolved gases in the solutions. Incidentally Mr. Griffiths remarked that he was able to measure temperatures to within three or four parts in a million.

Dr. R. A. Lehfeldt, at a subsequent meeting, called attention to a flaw in Nernst's theory of electrolytic solution pressure. According to this theory, when a metal is immersed in an electrolyte ions are torn either from the metal or from the solution according as the solution-pressure is greater or less than the osmotic pressure of the ions in solution. It is usually supposed that the mass of the ions deposited or dissolved is so extremely small that it cannot be detected; the author showed, however, by considering the electrostatic tension due to the ionic charges, that the amount dissolved should be easily weighable, at any rate in the case of zinc.

The stability of an ether containing long, thin, empty vortex filaments was discussed in a communication by Prof. FitzGerald on the energy per cubic centimetre in a turbulent liquid transmitting laminar waves. Lord Kelvin considered this subject in 1887, and concluded that rapid diffusion would make the structure unstable. The author held the opinion (though possibly Lord Kelvin would differ from him) that the turbulency of a sufficiently fine-grained irregularly turbulent liquid would ultimately diffuse so slowly that Lord Kelvin's investigation could be applied to it.

Until the meeting of the Association in 1893, it was generally supposed that the absence of an atmosphere from the moon, and of hydrogen from our own atmosphere, is due to the high average velocity of the gaseous molecules, which is sufficient to carry them beyond the range of the moon's or earth's attraction. On that occasion Prof. Bryan demonstrated the incorrectness of this view for the case of the moon, and he has since extended his calculations to the cases of hydrogen and helium in the

earth's atmosphere, and of water vapour in the atmosphere of Mars. The method of calculation is to determine the number of years which would be required for the planet to lose from its surface a layer of the gas one centimetre thick at various temperatures. The results show that the earth might retain helium, but would lose hydrogen appreciably at ordinary temperatures, and that Mars might retain water vapour at ordinary temperatures. If helium ever existed on the earth's surface, it must have escaped when the surface was much hotter than at present, whereas a smaller elevation of temperature would cause water vapour to escape from the surface of Mars.

Prof. W. F. Barrett described the thermo-electric properties of an alloy containing iron 68·8 per cent., nickel 25·0, manganese 5·0, and carbon 1·2. When a thermo-electric couple is formed of this metal and iron, the electromotive force rises with temperature to 300° C.; it then remains steady until 500° C. is reached, after which it falls slightly and rises again to 1100° C.; the fluctuations of electromotive force do not exceed 4 per cent. of the total value. When the alloy forms a couple with nickel the results are similar, but the range of variation is slightly greater.

The committee on the heat of combination of metals in the formation of alloys, appointed last year to assist Dr. A. Galt in his experiments on this subject, reported the completion of their work. Only alloys of zinc and copper have been examined, twenty-two in number and containing from 5 to 90 per cent. of copper; the difference between the amounts of heat evolved by dissolving in nitric acid unit mass of the alloy and corresponding amounts of the mixed metals was taken as the heat of combination of the metals. The results indicate a negative heat of combination for alloys rich in zinc, the numerical value of which is a maximum when the alloy contains 16 per cent. of copper. The formation of an alloy containing about 24 per cent. of copper takes places without absorption or evolution of heat, while for 38 per cent. of copper the heat of combination is a maximum and positive; beyond this it diminishes to zero for pure copper. In the absence of Dr. Galt and other members of the committee no reply was given to a serious criticism by Prof. Vernon Harcourt, that in the experiments no account was apparently taken of the fact that the products arising from the solution of an alloy in nitric acid are not the same as would be obtained from the mixed metals. In his paper read last year at Bristol, Dr. Galt mentioned that he had made many preliminary experiments, and possibly he has examined this point; if not, the results obtained by the committee will be somewhat vitiated.

A preliminary report of the committee on radiation from a source of light in a magnetic field was communicated to the Section, the chief points in which were (1) the discovery that light passing through a magnetic field at right angles to the lines of force suffers absorption (see NATURE, vol. lix. pp. 228–9, January 5, 1899); (2) the various modified forms of triplet are true magnetic perturbations of the same kind as the normal triplet; (3) the spectral lines of a substance may be divided into groups such that all members of one group suffer the same kind of perturbation (see NATURE, vol. lix. p. 248, January 12, 1899).

The Zeeman effect is attributed to the action of a magnetic field on the moving ions; recently Mr. C. E. S. Phillips has discovered an apparently cognate phenomenon, which he described in his paper on the production in rarefied gases of luminous rings in rotation about lines of magnetic force. An electric discharge is passed between soft iron electrodes in a Crookes' vacuum tube; on stopping the discharge and setting up a magnetic field between the electrodes, a luminous ring forms with its plane at right angles to the lines of force and in rotation about the magnetic axis. The direction of rotation is that which would be communicated to negatively charged particles, and is reversed on reversing the magnetic field; the luminosity persists sometimes for a minute, and reversal of the magnetic field causes it to brighten momentarily. Two explanations of the phenomenon have been given; one is that the rotating matter consists of ions or electrons, and the other that the matter consists of gas particles which have acquired a negative charge by contact with the walls of the tube. From experiments of Prof. J. J. Thomson, it appears that negative ions move more quickly than positive, which would account for the greater luminosity of the negative ions when set in rotation.

In a note on deep-sea waves, Mr. V. Cornish endeavoured to trace relations between the amplitude, wave-length, and wind-velocity for waves on the surface of deep water. Sir George Stokes pointed out that the amplitude observed is not that of a simple wave, but is the resultant effect of a train of waves of different periods and lengths.

At the meeting of the Section on Saturday the visitors from the French Association at Boulogne were present, and the President extended to them a hearty welcome, which was acknowledged by M. Benoit, as president of the Physical Section of the French Association. A paper was then communicated by Prof. J. J. Thomson, on the existence of masses smaller than the atoms. He stated that several lines of research lead to a determination of the ratio of the mass of an atom ($m$) to the charge carried by the atom ($e$). Among these are electrolysis, the velocity of charged particles in a magnetic field, and the magnetic deflexion of kathode rays. The two latter methods are comparatively simple, because they depend on the observation of luminous effects, but although they agree with each other fairly well, they furnish a value of $m/e$ which is about 1/1000 of that calculated from electrolytic phenomena. It becomes, therefore, a matter for inquiry whether in the former experiments the atom carries a charge greater than that required by Faraday's laws, or whether the charge is carried by a portion only of the atom—in other words, whether a small fraction of the mass of the atom is detachable which has associated with it a negative charge. The simplest crucial experiment is obtained by determining separately either $m$ or $e$, and the author has devised a means of measuring the latter quantity. He takes a negatively charged metal plate supported horizontally; below this and parallel to it is a very large perforated metal plate, the whole being in rarefied gas at a pressure of about 1/100 mm. mercury. When ultra-violet radiation is directed through the perforated plate to strike the upper plate the latter is discharged, the discharging particles moving along straight lines normal to the two plates. If a magnetic field be now excited with its lines of force parallel to the plates, the particles describe curved paths which are in fact portions of cycloids. When the plates are near together the particles which leave the upper one strike the lower one; if, however, the plates are separated further, the vertex of the cycloidal path comes between them, and the particles do not reach the lower plate, so that the discharge ceases. In the actual experiment there is a gradual, but not abrupt, change in the rate of discharge, possibly because all the particles do not start from the surface of the upper plate. From observations on the distance apart of the plates when the change in the rate of discharge commences, the form of the cycloidal path is determined, and the results show that the smaller value of $m/e$ is applicable to this case and to that of illumination by kathode rays. Further, the amount of electricity discharged by the illuminated plate per second is proportional to the number of particles between the plates, to the charge carried by each ($e$), and to the velocity of the particles. The last-named quantity is measured by a method due to Prof. Rutherford, so that if the total number of particles in the space is known the value of $e$ can be determined. To count the particles use is made of the fact that they serve as nuclei for the formation of drops out of a condensing vapour, each particle giving rise to one drop. Let a known amount of air of given humidity be suddenly and definitely expanded in the presence of the particles, and observe the rate at which the drops fall; this rate gives the size of the drops, and hence their mass, and since the whole mass of water deposited is known, the number of drops is thus determined. For negative charges the ratio $m/e$ is independent of the nature of the gas, whereas for positive charges its value varies from one gas to another, and corresponds generally with the values given by electrolytic phenomena. Prof. Thomson considers that electrification consists in the removal from the "atom" of a small corpuscle with which the negative charge is associated; the remaining large portion of the mass is positively charged. This view is supported by Prout's hypothesis that the mass of an atom is not invariable, and by the evidence derived by Lockyer and others from spectroscopic observations.

In the discussion which followed upon Prof. Thomson's paper, M. Broca described spectroscopic observations of a spark obtained between two platinum electrodes ½ mm. apart in a Crookes' vacuum tube; the spectra of the regions near the electrodes and the space between them were not alike. Prof. Rücker drew attention to Schuster's experiments, in which the spectrum of a substance not present in the material examined sprung into being in the arc itself. He believed matter to be a

complicated collection of units themselves similar. Sir Norman Lockyer said that if we accept the view that elements of smallest atomic weights should appear first in the spectrum of a hot star, we must assume the existence of forms of calcium, magnesium, iron and copper having atomic weights which are submultiples of those assigned to them in ordinary chemistry. Further, the division of the spectra of certain elements into series of lines by Rydberg, Runge and Paschen, and others indicates that the atoms of these elements are complexes; we have, therefore, no reason to suppose that the so-called "atoms" are not dissociable at high temperatures. Prof. Oliver Lodge thought the investigations of Prof. Thomson might turn out to be the discovery of an electric inertia, and lead to a theory of mass. Several speakers expressed their pleasure in receiving the members of the French Association.

In the very short time remaining after the discussion on the previous paper, Prof. Oliver Lodge gave a short account of the controversy respecting the seat of Volta's contact force.

On Monday the Section was subdivided for papers on mathematics and meteorology respectively. In the latter department, over which Sir George Stokes presided, a formal report was presented by the committee on solar radiation. Dr. van Rijckevorsel read a paper in which he traced an intimate connection between the activity of sun-spots and the temperature. The committee on seismology presented a voluminous report on their work, from which it appears that twenty-three stations are now equipped with recording seismographs, and registers have been received from ten of these. Notes on these registers occupy a considerable portion of the report; the rest of the report is abstracted from articles which have already appeared in NATURE (February 16 and March 1, 1899). Mr. T. F. Claxton communicated the preliminary results of a year's work with the seismograph at Mauritius. The diurnal waves are of greater amplitude than at any other observing station, and there is a well-marked bi-diurnal effect possibly connected with barometric pressure. Rapid and large changes of the vertical have occurred on several occasions, in addition to a constant gradual change. Air tremors have given trouble at night. The earthquake effects have been of disappointingly small amplitude, and it is suggested that the ocean may act as a damper to earthquake shocks.

Mr. A. L. Rotch gave an interesting account of the progress achieved during the past year at Blue Hill, Massachusetts, in the exploration of the air with kites. The Hargrave kite with curved surfaces has been found more satisfactory than any other form, and the meteorograph records temperature, humidity, height and wind. Temperature is found to decrease at first with elevation, and afterwards to increase again. The heights attained were on the average greater than in previous years. The author mentioned that the United States Government has arranged for daily simultaneous observations at two heights in the case of a number of stations, the kite being used for the high-level observations. The results are not quite satisfactory, because kites could not be sent up on some days; it is suggested that on such occasions a captive balloon be employed. Prof. Thomson hoped that the variation of atmospheric electric potential would be investigated by means of kites. Prof. G. H. Darwin regretted that on account of the non-existence of a Government meteorological observatory, this country is very backward in the adoption of recent methods of meteorological research. In a subsequent paper Mr. Rotch gave an account of the first crossing the Channel by a balloon, by Dr. Jeffries and M. Blanchard in January 1785. The former was a Harvard graduate in medicine, who settled in London, and the latter a French professional aëronaut. The expedition was of a scientific character.

A description of the hydro-aërograph, an apparatus invented by Mr. F. Napier Denison for registering small fluctuations of level of the American lakes and simultaneous small changes of air-pressure, was read by Mr. W. N. Shaw. The apparatus is designed to study more minutely an observed effect of barometric changes on the surfaces of the great American lakes.

The Ben Nevis committee presented the usual summary of their records, and stated that the conclusions arrived at last year with reference to the effects of approaching cyclones and anti-cyclones on the two observatories are supported by the examination of later records. The committee on meteorological photography reported having obtained photographs of some rare forms of cloud and some studies of lightning flashes; the structure of thunderclouds appears to resemble two parallel discs of cloud, with lightning flashes passing between them or from one face to the other of either cloud.

On Tuesday, Prof. Threlfall described a portable gravity balance, designed by Prof. Pollock and himself, for the measurement of small differences in the intensity of gravity from place to place. It consists of a light wire attached near one end to the centre of a horizontally stretched and twisted quartz fibre, the moment of the weight of the wire just balancing the torsional moment of the fibre. The wire is only just in stable equilibrium, and the torsion of the fibre is noted when the wire is adjusted to coincide with the axis of a microscope carried on the frame of the apparatus. The instrument can now be relied upon to 1 part in 500,000, but the accuracy of single readings is greater than this. It has been severely tested by much travelling on the Australian coast.

The committee on electric standards reported that Profs. Ayrton and J. V. Jones have now completed the plans and specifications for the ampere balance to be used in constructing an ampere standard. The committee will consider the proposals of Prof. Callendar for the construction of a standard platinum thermometer in terms of which all other platinum thermometers can be compared. The report contains the results of a determination of the coefficient of expansion of porcelain, by Mr. T. G. Bedford, which was undertaken in order to compare the scales of temperature and platinum thermometers of air.

Prof. Callendar opened a discussion on platinum thermometry, in which he advocated the adoption of the variation of resistance of platinum as a basis for a *practical* scale of temperature. He suggested the construction of a standard thermometer from a particular sample of platinum wire, and the use of a parabolic difference formula for the determination of temperature by its means. The difference-coefficient may be obtained by using as a secondary fixed point the boiling point of sulphur (444·53° C. at normal pressure). Dr. J. A. Harker described the method used, and Dr. Chappuis the results obtained, in a comparison of platinum and nitrogen thermometers at the International Bureau of Weights and Measures at Sèvres. The results agree fairly well with those of Callendar and Griffiths in the comparison of the air and platinum thermometers. In the discussion Mr. E. H. Griffiths advocated the use of the platinum thermometer on the ground that only three readings are necessary in order to standardise any instrument. Prof. Carey Foster was of opinion that the electrical method would furnish a good intermediate standard; for absolute values, however, the gas thermometer must be used, because there is no theory of the variation of electrical resistance with temperature and only an empirical knowledge of it. Prof. Burstall described experiments supporting the proposals of Prof. Callendar. Principal Glazebrook thought that, before taking platinum as a standard, experiments should be undertaken to ascertain whether it is superior to other metals, for instance gold. Dr. Chree said that some platinum thermometers purchased by the Kew Observatory had exhibited curious tricks, and were far from satisfactory, because the reasons for departure from accuracy were numerous and not always discoverable. In the case of mercury thermometers the zero certainly alters, but the change has a known cause, and can be allowed for. Prof. Threlfall remarked that for rapid and accurate work the platinum thermometer alone could be used; the enormous heat-capacity of a mercury thermometer rendering it quite unserviceable. Mr. W. N. Shaw thought the thermo-electric couple methods, upon which the Germans are concentrating their attention, ought to be compared with the platinum thermometer before deciding upon a standard. In reply, Prof. Callendar said that methods based on the use of a thermo-electric couple are not sensitive at low temperatures.

On Wednesday, Dr. L. A. Bauer described the arrangements made by the United States Coast and Geodetic Survey for the proposed magnetic survey of the United States and Alaska, and expressed a hope that the Canadian Government would consider the possibility of a simultaneous survey of Canada. Dr. Bauer also described the results of a magnetic survey of Maryland. Dr. E. P. Lewis, in a paper on the spectral sensitiveness of mercury vapour in an atmosphere of hydrogen, described the appearance and intensity of the spectrum of a mixture of hydrogen and vapour of mercury in varying proportions. Mr. J. Gifford, who has measured the angles of prisms of quartz and calcite, and the corresponding minimum deviations for the mean of the sodium lines, at various temperatures, gave an account of the variation of refractive index with temperature in these cases.

The proceedings of the Section closed with votes of thanks to the president and secretaries, proposed by Prof. Forsyth, and seconded by Prof. Reinold.

## *UNIVERSITY AND EDUCATIONAL INTELLIGENCE.*

OXFORD.—The following are among the lectures and practical courses announced for the present term:—General Pathology, Sir J. Burdon-Sanderson; The Chemical Processes of the Body, Prof. F. Gotch; Elementary Physiological Chemistry, W. Ramsden; Practical Histology, G. Mann; Elementary Medicine. W. Collier; Minor Surgery, A. Winkfield; Human Osteology, Prof. A. Thomson; Analytic Theory of Plane Curves, and Synthetic Theory of Plane Curves, Prof. W. Esson; Elementary Mathematical Astronomy, Prof. H. Turner; Physical Crystallography, Prof. H. Miers; Practical Crystallography, H. Bowman; Electricity and Magnetism, Prof. A Love; Theory of Numbers, Prof. E. Elliott; General Morphology, and Variation Inheritance and Natural Selection, Prof. W. Weldon; Experimental Physics, Prof R. Clifton; Structure of Simple Machines, Rev. F. Jervis-Smith; Silicon and Boron Compounds, Prof. W. Odling; Subjects of the Preliminary Examination in Chemistry, Dr. W. Fisher; Organic Chemistry, J. Watts; Physical Chemistry, V. Veley; Metabolism, J. Haldane; Muscular Activity, Prof. F. Gotch; Physiological Physics, G. Burch; Physical Geology, and Jurassic Fossils, Prof. W. Sollas; Elementary Botany, Prof. S. Vines; Classification of Mankind by Race, Language and Civilisation, Prof. E. Tylor; Bacon, and the Organon of Aristotle, Prof. T. Case; Mental Evolution, G. Stout; Inference and Scientific Method, J. Cook Wilson.

CAMBRIDGE.—Mr. John Sealy Edward Townsend, who entered the University as an Advanced Student in Physics, was on October 9 elected to a Fellowship in Trinity College.

Dr. W. E. Dixon, late Salters' Research Fellow in Pharmacology, has been appointed Assistant to the Downing Professor of Medicine.

Dr. L. Humphry has been appointed Assessor to the Regius Professor of Physic.

A Scholarship of 50*l.* in Natural Science will be open for competition at Downing College to members of the University of less than four terms' standing on Monday, November 27. Applications are to be made to the Tutor.

Studentships for research have been awarded at Emmanuel College to R. G. K. Lempfert and B. W. Head.

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A GENERAL meeting of Convocation of the University of London was held on Tuesday to receive an interim report from the special committee appointed on June 27 to make representations to and to confer with the London University Commissioners, the Senate, and other bodies with reference to the scheme of the Royal Commission. On the subject of faculties contemplated under Section 10 of the Schedule of the University of London Act, the special committee made various recommendations, among which the following may be noticed:—There should be only one faculty of science with adequate representation on the Senate and the Academic Council. Engineering should be a distinct branch of the one faculty of science and not a separate faculty, but degrees should be given in engineering bearing a distinctive name. If it should be thought expedient to constitute a distinct branch of the faculty of science for any other scientific profession, there is not, in the opinion of the committee, any present occasion for giving a distinctive name to degrees to be taken in that branch. If, contrary to the opinion of the committee, the subjects of the faculty of science should be divided by the commissioners, for electoral purposes, into several faculties, the committee hope they may be afforded an opportunity of giving further consideration to the principles upon which such division should be effected, especially in connection with the effect which the division would have upon the University examinations and degrees. After discussion it was decided "that the report be received subject to the reconsideration by the committee of such points, if any, as this house may deem advisable."

## *SOCIETIES AND ACADEMIES.*

PARIS.

Academy of Sciences, October 2.—M. van Tieghem in the chair.—The Mayor of Chantilly informed the Academy that the inauguration of the statue erected to the Duc d'Aumale would take place on October 15.—Orbit of the shooting star of August 24, by M. J. Comas Sola. This meteor, which was a very bright one, was observed at the Observatory of Català, had a relative direction nearly east to west, disappearing near $\alpha$-Capricorn. Its absolute velocity was 50 kilometres per second. A similar meteor was observed on August 28 at 7.45, but of smaller lustre.—On the identity of solution of certain problems of elasticity and hydrodynamics, by M. Georges Poisson. In a note presented to the Academy on May 2, 1898, M. Maurice Lévy remarked that in problems of elasticity in two dimensions the distribution of the pressures is independent of the value of the elastic coefficients. In the present note it is shown that in this case the determination of the pressures may often be reduced to the study of the permanent motion of a liquid.—On two chlorobromides of tungsten, by M. Ed. Defacqz. In an attempt to prepare tungsten hexabromide, tungsten hexachloride was sealed up with liquid hydrobromic acid in excess, and the whole heated at 70° for four hours. The resulting product was not the desired hexabromide, but a chlorobromide having approximately the composition $WCl_6.3WBr_6$. In a second similar preparation the tube was not heated, but left for three days at the temperature of the laboratory; the substance obtained was another chlorobromide, represented by the formula $WCl_6.WBr_6$.—On copper hypophosphite and its decomposition by precipitated palladium, by M. R. Engel. Aqueous solutions of copper sulphate and barium hypophosphite are mixed in equal molecular proportions, the solution filtered, and the copper hypophosphite precipitated in the crystalline form by the addition of alcohol in excess. The solution of the salt is decomposed in a remarkable manner by the addition of precipitated palladium, copper being thrown down and hydrogen gas evolved according to the equation

$$Cu(PO_2H_2)_2 + 2H_2O = Cu + 2H_3PO_3 + H_2,$$

no copper hydride being formed. In the absence of palladium the copper hypophosphite is decomposed differently by heat, copper hydride being first formed, and then metallic copper, phosphorous and hypophosphorous acids.—Salicylic and paraoxybenzoic aldehydes and salicylhydramide, by MM. Delépine and Rivals. A thermochemical paper.—On a double monstrosity observed in the blastoderm of a fowl's egg in the course of formation, by MM. Bonmariage and Petrucci.—Completion of some observations on the Alps of the Vaudois, by M. Stanislas Meunier.—On an aërial voyage of long duration, from Paris to the Mediterranean, carried out on September 16 and 17, by M. Gustave Hermite.—Barometric deviations on the meridian of the sun on successive days of the tropical revolution of the moon, by M. A. Poincaré.

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THURSDAY, OCTOBER 19, 1899.

## *ELECTRO-MAGNETIC THEORY.*

*Electro-magnetic Theory*. Vol. ii. By Oliver Heaviside. Pp. xvi + 542. (London: The *Electrician* Co., Ltd.)

THIS interesting work, the first volume of which appeared some five years ago, well sustains Mr. Heaviside's reputation as an original investigator, and even when we do not agree with his procedure, we must admire his fertility of resource and the skilful manner in which he develops his methods. Although we are more than once warned that the treatment is not formally or logically arranged, as is indeed the case, Mr. Heaviside has nevertheless, in essentials, admirably arranged his matter, so that we are led on by gentle steps from comparatively simple to more complex problems.

The book may be regarded from two distinct points of view. Firstly, without inquiring too closely into the validity of the mathematical methods employed, we may consider the work from a physical point of view as a mathematical theory of the propagation of plane electromagnetic waves in conducting dielectrics, according to Maxwell's theory, or as the theory of the propagation of waves along wires. Secondly, we may consider the book from a purely mathematical point of view as an introduction to the theory of generalised differentiation, divergent series, and Bessel's functions, viewed, however, for the most part through physical spectacles.

The book opens with a discussion of the age of the earth, in which Prof. Perry's results are explained and contrasted with those of Lord Kelvin. Then follows a discussion of the equations

$$-\frac{dV}{dx} = RC, \qquad -\frac{dC}{dx} = SpV$$

where V and C are the voltage and current, R and S the resistance and permittivity per unit of length, and $p$ stands for $\frac{d}{dt}$. A large number of problems are considered in some detail, and it is very noticeable how easily terminal conditions are dealt with by Mr. Heaviside's methods, and in this respect they have a great advantage over Fourier's method. The more general equations

$$-\frac{dV}{dx} = (R + Lp)C, \qquad -\frac{dC}{dx} = (K + Sp)V$$

where L is the inductance and K the leakance, as Mr. Heaviside terms it, per unit of length, are next considered. These in the case where $1/R$, $1/L$, K and S all vary as the $n$th power of the distance from $x=0$ lead to Bessel's functions. As before, a great variety of interesting and important questions are dealt with, and Mr. Heaviside is careful to explain that these are not mere mathematical exercises, but that the formulæ apply to cylindrical electro-magnetic waves. The case of R, L, K, S, constants is discussed at some length, and owing to the application of the results to practical questions concerning telegraph and telephone cables they should be kept in mind by "practicians." Mr. Heaviside has for long been preaching in the wilderness on this matter, but his labours will bear fruit one day, and we trust that when the day comes it will not be a case of "tulit alter honores," as has happened to other men in other matters. Some sections are devoted to discussions of the experiments of Dr. Barton and Dr. Bryan, of spherical waves, and, with some reserve, to the experiments of Hertz and Lodge. The sections on spherical waves have, as is pointed out by the author, a practical application in wireless telegraphy. Some rough, but interesting, curves showing the progress of a wave under various circumstances conclude the physical portion of the work.

Passing on to the mathematical aspect of the book, operational methods are freely employed, and their reduction to algebraical form leads us at an early stage of the work to the question of fractional differentiation. This is a subject which has frequently occupied the attention of mathematicians, and two main modes of proceeding have been proposed, one taking $e^x$, the other $x^n$ as the fundamental symbol; the first method was employed by Liouville and Kelland, the second by Peacock. Both methods find formulæ which are certainly true when the index of the operating symbol is an integer, and for the case of the index or fraction both appeal to the principle of the permanence of algebraical forms. If both methods produced the same result in every case all might be well, but most unfortunately this is not so, at least without some further assumption, and it is a question beset with difficulties which system, if either, is to be considered the true one. Mr. Heaviside's method evades rather than elucidates the difficulties. He requires to find the value of $p^{\frac{1}{2}}1$, where $p = \frac{d}{dt}$, and 1 is that function of $t$ which is zero before and unity after $t=0$. To effect this he takes a suitable physical problem, and, solving symbolically, obtains a solution involving $p^{\frac{1}{2}}1$; then by another method he finds a solution free from operators; a comparison of the two gives $p^{\frac{1}{2}}1 = (\pi t)^{-\frac{1}{2}}$. This is the same value as is given by Peacock's method, but not that which is given by Liouville's and Kelland's without further assumption. In Chapter vii. another way, on the same lines as before, is given of finding this result, and the remark is added, "I do not give any formal proof that all ways properly followed must necessarily lead to the same result." It is much to be regretted that no hint is given on this point, for, granting that there is a theory of fractional differentiation, the way to be properly followed is the essence of the whole matter.

Some of Mr. Heaviside's methods of dealing with series in Chapter viii. are also open to some objection; he more than once tests the equivalence of two series by giving the variable numerical values and seeing if the two series give the same result. This may be an "excursion to the borders of the realms of duplicity," but scarcely to those of "fearful rigour." It would seem, indeed, from many passages in the book, that Mr. Heaviside considers rigour in mathematics to be of somewhat minor importance; for instance:

> "You have first to find out what there is to find out. How you do it is quite a secondary consideration."

If this advice were to be generally followed, mathematicians would no doubt jump many gates in their endeavours to reach the goal on the other side, but whether or no they would not at times land in a quagmire may be open to doubt.

Mr. Heaviside's treatment of Bessel's functions is interesting and suggestive, but the lack of formal arrangement is here severely felt; it is not always easy to distinguish clearly between what is proved and what is experimentally assumed to see how it goes as Mr. Heaviside puts it. The student who is previously unacquainted with the properties of these functions will probably find difficulty in following some of the equations written down without proof. In the equation for $K_0 (qx)$, p. 226, for example, all the information given about $\gamma$ (Euler's constant, but not distinguished as such) is "where $\gamma = 0{\cdot}5772$ is a certain constant introduced to make $K_0 (qx)$ vanish at infinity"; certain of the conjugate relations are also without proof, but these possibly are left as exercises for the student.

The work is nevertheless one which will well repay careful attention. As has been remarked by Prof. De Morgan:

"The history of algebra shows us that nothing is more unsound than the rejection of any method which naturally arises, on account of one or more apparently valid cases in which such methods lead to erroneous results. Such cases should indeed teach caution, but not rejection."

Mr. Heaviside is much to be congratulated on the light he has thrown on difficult and perplexing questions in both physics and mathematics, and also for calling the attention of mathematicians to a powerful, but somewhat neglected, weapon. C. S. WHITEHEAD.

## OUR BOOK SHELF.

*Catalogue of the Lepidoptera of Northumberland, Durham and Newcastle-upon-Tyne.* Part I. By J. E. Robson. *Nat. Hist. Trans. of Northumberland, Durham and Newcastle-upon-Tyne*, Vol. xii. Part 1. Pp. 195.

THE present instalment of this important catalogue includes the butterflies, together with such of the moths as are comprised in the *Sphingina* (hawk-moths), *Bombycina*, and *Noctuina*. In his classification the author thus far follows Mr. Barrett's monograph of the British Lepidoptera, to the unpublished portions of which he has been supplied with references by Mr. Barrett himself. Whatever faults there may be in the scheme of classification in question, and the nomenclature employed therein, the adoption of a uniform system by different writers is highly desirable; and we, therefore, consider that Mr. Robson has been well advised in the course he has adopted.

As the author has had the advantage of the cooperation of all the local collectors of repute, his work may be regarded as a thoroughly up-to-date account of the Lepidopterous fauna of the northernmost counties of England. And how different this fauna is from that of the midland and southern counties may be gathered from a glance at the portion devoted to the butterflies. The common Brimstone Butterfly, for example, is only known in the area treated of by two or three stragglers, its normal range not extending northwards of South Yorkshire. Much more remarkable, however, is the circumstance that certain species of butterflies, such as the Comma and the Red Admiral, which were once common in the two counties, have for the last forty years been extremely scarce, although the second of the two mentioned has once again become a familiar object since 1893. It would be interesting to know the reason why so many of these insects left the district during the sixties; but on this point the author is silent. On the other hand, as might perhaps have been expected, migratory species, such as the Clouded Yellow and the Camberwell Beauty, which visit England at uncertain intervals in larger or smaller numbers, commonly travel into the northern counties; the author remarking of the last-named insect that it "visits these counties on most of those rare occasions when a wandering horde strikes our shores." Of the moths, it must suffice to say that the Death's-head has occurred in both counties, and there is reason to believe has bred in them, but that the stock is probably maintained by immigration from the south.

The foregoing instances demonstrate that Mr. Robson's work is very far from being a mere dry catalogue; and that it really teems with interesting observations on the life-history and distribution of all the species recorded. If the sequel be maintained at the same high level, the complete catalogue ought to prove a very important contribution to entomological literature. R. L.

*The Process Year-Book for* 1899 ("Penrose's Pictorial Annual"). Edited by William Gamble. Pp. viii + 108. (London: Penrose and Co., 1899.)

THIS is the fifth year's issue of this most excellent review of the graphic arts, and the editor, together with all his co-workers, are to be congratulated on the production of such a handsome and interesting volume.

As in former years, most of the articles are written by those who are at work in some line of process work, and as these are by no means few in number, the reader is made acquainted with a great amount of experience which may help him to success in the future. The feature of the book is undoubtedly the beautiful illustrations, which bring home to the reader the high state of excellence that the art of reproduction has reached at the present day. All kinds of subjects, from a stellar cluster down to an orchid, are illustrated, and these serve as types for showing the results obtained by the working of different processes.

The high order of merit attained should not only render the book a valuable aid to the process worker and others interested in the art of reproduction, but should find many other friends who would delight to possess such a charming collection of high-class illustrations.

*Mathematical Tables.* By James P. Wrapson and W. W. Haldane Gee. Pp. 28. (London: Macmillan and Co., Ltd., 1899.)

THIS set of useful tables in a compact form are abstracted from the compilers' larger volume of "Mathematical and Physical Tables." The idea of this present issue is to place before students tables which are suitable for the class and laboratory, and which give sufficient accuracy for such computations.

To sum up the contents, we have four place logarithms and antilogarithms, natural sines, cosines, and tangents, with interpolation to 1′. Logarithmic sines, cosines, and tangents with differences also to 1′. Tables of squares, exponential functions, weights and measures, and finally a table of conversion for the last mentioned.

*Opinions et Curiosités touchant la Mathématique.* By G. Maupin. (Paris: Carré et Naud, 1898.)

THIS is a collection of curious ideas and essays, which the author has encountered in the course of much heterogeneous reading in ancient scientific works, in which there has been found any reference however remote to mathematical thought. Paradoxes and absurdities alone seem to be considered worth inclusion; the book is of little or no use as a contribution to the history of mathematics.

## LETTERS TO THE EDITOR.

*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### Peripatus in the Malay Peninsula.

MY friend Mr. Richard Evans, of Jesus College, Oxford, now in the Malay Peninsula with the Skeat Expedition sent out by the University of Cambridge, writes to me that he and subsequently other members of the expedition have discovered Peripatus. His letter, written from Aring, Kalantan, and dated August 27, states that he had found two specimens about three months previously. The locality is given as "one of the mountains here." For some months after this discovery no further specimens were found, in spite of much searching. A little before the date of his letter, however, Mr. Laidlaw, of Cambridge, had found five and Mr. Evans six additional specimens, thus bringing up the number to thirteen.

The eleven specimens which were obtained last were found in two groups of five each, while a single individual was discovered by itself in the rotten tree in which one of the groups occurred.

The individuals of a group differed much in size, although each group was probably a brood.

The colour of the specimens is chocolate-brown above with numerous small pale spots, the under-surface being pinkish yellow with a nearly white spot between the feet of each pair.

The number of pairs of feet varies from twenty-three to twenty-five, the latter number occurring in the largest and presumably the oldest specimens.

Mr. Evans has asked me to embody these facts in a note to NATURE, and I feel sure that they will be of great interest to all naturalists. EDWARD B. POULTON.

Oxford, October 13.

### Dark Lightning Flashes.

THE paper by Mr. A. W. Clayden, referred to in my lecture from which Dr. Lockyer quotes (p. 570 *ante*), is entitled "Note on some Photographs of Lightning and of Black Electric Sparks," and is to be found in the *Proceedings* of the Physical Society, vol. x. p. 180, having been read on June 22, 1889. The author's photographs were exhibited at the meeting, but were not printed with the paper.

The following extract shows that some of Mr. Clayden's observations were very similar to those described by Dr. Lockyer. He photographed some electric sparks of different intensities, "and before developing the plates exposed them to the diffused light from a gas flame. The brilliant sparks then yielded images which may either be called normal with a reversed margin, or reversed with a normal core. The fainter sparks were completely reversed. . . . The reversal seems to spread inwards as the exposure to diffused light is increased." If the section of a flash is approximately circular, the luminosity would naturally be greatest along the middle, gradually falling off towards the edge.

It was of course known long before the date of Mr. Clayden's paper that the bright parts of a photograph might be reversed by the action of diffused light before development (Sutton's "Dic. of Photography," edition of 1867, p. 299).

I think it hardly possible that any lightning flash would be sufficiently brilliant to give a photographic image with a dark core and bright edges—Nos. 5 and 6 of Dr. Lockyer's list. The image of the sun itself is not generally reversed, unless with comparatively long exposure. The picture in the *Strand Magazine* (vol. xiii. p. 44, Fig. 10), which I understand to be the only apparent example of this class of reversal which Dr. Lockyer has met with, seems to me, from considerations of perspective, to represent beyond question merely a close double flash, two connected discharges having taken the same path through a moving body of air.

Dr. Lockyer's convincing article has no doubt finally disposed of the dark flash as an objective reality. It is to be hoped that so-called "ribbon lightning" will soon follow in its footsteps. SHELFORD BIDWELL.

### Heredity and Variation.

THE interesting suggestion made by Prof. Adam Sedgwick in his Dover address—to the effect that variability has decreased and heredity increased, so to speak, as evolution has progressed—leads me to call attention to the work of certain other writers. Prof. Bailey, of Cornell University, in his work "The Survival of the Unlike" (Macmillan) argues in detail for a similar view, *i.e.* that heredity has been gradually "acquired," while variability has been reduced. His book deals largely with evidence from plants. He stated the view earlier in certain papers. Moreover Prof. Williams, of Yale University, independently took up a like position at about the same time in several papers, the latest one having been read and discussed before the Society of American Naturalists at Ithaca, N.Y., December 1897, and subsequently printed in *Science*.[1] The point of view has become fairly familiar to American biologists. Indeed the editor of *Science* has referred to it as one of the two most important recent suggestions in the theory of evolution. As Prof. Sedgwick does not refer to these writers—though he may intend to do so in the fuller discussion which he promises—his readers to whom the suggestion appeals may find it worth while to look into them. The work of Prof. Bailey—who is a natural selectionist among botanists!—is remarkable from other points of view as well.

Oxford, October 10. J. MARK BALDWIN.

[1] I regret that absence from my library makes it impossible for me to give the exact references to his papers and to Prof. Bailey's.

### Phosphorescent Earthworms.

IN a recent issue of NATURE (during May of the current year) Mr. Beddard, in referring to the phosphorescence of *Microscolex* (*Photodrilus*) and of *Allolobophora foetida*, suggests that this phenomenon is exhibited by the slime secreted by the epidermis. Will you allow me to mention my observation on a New Zealand worm that indicates that the matter is worthy of re-investigation?

Our large white earthworm (*Octochoetus multiporus*) has a milk-coloured cœlomic fluid of very great tenacity; it can be drawn out into strands, and soon hardens on exposure to air. In the dark, when the worm is handled, this fluid is discharged abundantly from the dorsal pores and from the mouth, which it reaches through the "peptonephridia" opening into the buccal cavity. The fluid is brilliantly phosphorescent when freshly discharged, and the fluid sticks to one's fingers very persistently; but it soon loses its phosphorescence. I wish here merely to point out that the luminosity is due to the cœlomic fluid in *O. multiporus*, and I believe that further examination will show that the same is true of *A. foetida*.

The fluid in *O. multiporus* contains numbers of "elæocytes," which are present also in *A. foetida* and other European worms; but in the New Zealand worm they are colourless, not yellow. A very remarkable kind of corpuscle is also present, viz. a cell containing a threadlike structure not unlike those described by Goodrich in an enclytrœid a few years back. I am now endeavouring to locate the phosphorescence—that is, to ascertain which of these two cells is the seat of the phenomenon.

Dunedin, N.Z., August 5. W. BLAXLAND BENHAM.

## MEETING OF THE INTERNATIONAL METEOROLOGICAL COMMITTEE.

THE Committee met at St. Petersburg from September 2–7; the meeting was a small one, only about half of the members being present. It was opened by the Grand Duke Constantine, who delivered an interesting address, in which he specially referred to the service rendered to meteorological science by A. Kupffer, the founder of the Russian climatological organisation. The reports of the various sub-committees were read and considered, and the following are the principal resolutions arrived at:—On the report, by Prof. Rücker, upon terrestrial magnetism and atmospheric electricity, it was decided that the sub-committee should be maintained as a distinct organisation, under the direct supervision of the International Committee. In reply to a question by

General Rykatcheff, director of the Russian Meteorological Service, the Committee recommended that meteorological institutions should take part in observations of earthquake phenomena. With regard to Antarctic exploration, the Committee expressed the opinion that it is highly desirable (1) that the results of these explorations should be completed by data from the observatories already existing in the southern hemisphere, and by those made on board vessels traversing the southern oceans; (2) that new meteorological stations should be established in the southern part of the Antarctic regions, and especially that magnetic observations should be organised; (3) that magnetic determinations over the whole globe should be made simultaneously with those made during the expeditions. With reference to the valuable researches of Dr. Hildebrandsson relating to the great centres of action of the atmosphere (which have already been noticed in our columns), the following resolution was adopted:—"The Committee appreciates the high interest attached to observations made in a regular manner in different regions which seem to possess special importance as to our knowledge of the general laws of the motions of the atmosphere." Profs. v. Bezold and Mascart drew attention to the proposed establishment of a very complete meteorological and magnetical observatory at the Azores by the Prince of Monaco, assisted by Captain Chaves, of the Portuguese navy, who has entirely devoted himself to the realisation of this undertaking. On the question of the calculation of daily meteorological means, it was decided that if the exact formula

$$\frac{0+24}{2}+1 \ . \ . \ . \ +23:24$$

is not adopted the midnight observation should be taken into account at the end of the day, as is already done at most stations, according to the formula

$$1+2+3 \ . \ . \ . \ +24:24.$$

On the proposal of Dr. Hann to publish tables of diurnal range of temperature for each country in a special form, the Committee, while appreciating the interest and importance of the proposal, expressed its opinion that, as the question possessed a general bearing, it should be examined by a sub-committee, which should determine the form of table to be adopted by all countries. On the subject of the importance of actinometric observations, also brought forward by Dr. Hann, the Committee expressed the hope that the sub-committee for terrestrial and solar radiation would present a report upon that subject at the next International Congress. M. Violle submitted a note on the various methods employed for actinometric measurements. On the proposal of Dr. Pernter as to the desirability of the restriction of observations with the wet-bulb thermometer and the multiplication of observations with the hair hygrometer, the Committee came to no decision, pending the presentation of a full report upon the question. Dr. Paulsen, director of the Danish Meteorological Institute, drew attention to the importance for weather prediction of the laying of a cable between Iceland and Europe, towards which the Danish Government and the Great Northern Telegraph Company were prepared to make a considerable annual subvention. The Committee fully recognised the importance of the proposal, and expressed its hope of the ultimate success of the project. Profs. Neumayer and v. Bezold made a proposal relative to the publication of an international periodical weather report (recently referred to in our columns), which should contain ten-day means from about a hundred stations. The Committee was of opinion that it would be desirable that a definite plan of the proposed publication should be prepared for examination by each meteorological service. A sub-committee, composed of MM. Pernter (president), Billwiller, Neumayer, Rykatcheff, Mohn and Tacchini, was nominated for the purpose of considering the extension and improvement of international telegraphy for weather prediction. Finally, it was decided that the International Meteorological Committee and the various sub-committees should meet in Paris in the year 1900, immediately after the Meteorological Congress which will take place on the occasion of the Exhibition. This Congress will probably be held during the first half of September. We are indebted to M. Lancaster's summary in *Ciel et Terre* for the notice of this meeting.

## *THE COMING SHOWER OF LEONIDS.*

DURING the past few years English observers, in their efforts to witness returns of the Leonid meteors, have met with little but disappointment. Either the firmament has been overcast at the important time, or the display has been very weak. The rarity and singular attractiveness of a really fine meteoritic exhibition are such that the immediate prospect of viewing an event of the kind has aroused great interest in the whole subject of shooting stars. But we have been a little premature in our anticipations in recent years, and looking for the appearance of the meteors before the vanguard of the denser portion of the stream had begun to cross the earth's path. There can, however, be no doubt as to the character of the ensuing display. The earth will be sure to encounter one of the richest regions of the orbit at the middle of November, but whether or not this collision will occur at an hour perfectly suitable for its observation remains to be seen. It must be admitted that the exact time of the *rencontre* cannot be definitely stated. The materials upon which computations have to be based are not sufficiently numerous and consistent to enable exact deductions to be drawn from them. Moreover, there is evidence to show that the system of meteors is constantly undergoing changes. The particles are spread out, and are still spreading out, over a very considerable section of the orbit, and are subject to perturbations by the larger planets. Different sections of the stream are affected unequally, so that the whole system, both as regards its conformation and distribution, suffers from such irregular disturbances, that we must be prepared for the visible signs of developments of an unexpected character. In the present state of our knowledge it is impossible for us to allow for all the various circumstances and conditions which control the visible aspect of the shower, from year to year, and modify its orbital elements.

Calculations which have been made independently by several authorities show that the influence of Jupiter and Saturn, since the last return of the shower in 1866, has been exerted in increasing the node, so that the phenomenon may be expected a day late in the present year It will probably occur just before sunrise on November 16. Drs. Stoney and Downing, in a paper published in the *Proceedings* of the Royal Society, vol. lxiv. p. 406, state that a noteworthy outcome of their investigations is that the meteor-group which gave rise to the display in 1866, made a near approach to Saturn in 1870, and to Jupiter in 1898. On the latter occasion the meteor-cloud was distant from Jupiter by an interval of space less than that separating the earth and the sun. Berberich (*Ast. Nach.*, 3526) has also discussed the orbit-perturbations of the Leonid stream, and concludes that the meteors will appear about a day later than they would have done under normal conditions. If there had been the average annual displacement of the node (equal $102''\cdot6$) the recurrence of the shower might have been anticipated on November 15 at about 1 a.m., but the perturbations seem to have increased the longitude of the node to the extent of $1\frac{1}{4}^\circ$; so that the greatest intensity of the display must be awaited on the morning of November 16, in the twilight preceding sunrise.

But it must be admitted that these deductions are liable to some uncertainty. Last year the predicted late-coming of the meteors was far from being corroborated by observation. The maximum number of meteors was recorded on the morning of November 15, and very few Leonids were presented on the following morning, though computation had indicated the latter as the time of maximum. In view of the prevailing doubts there seems no alternative but to watch for the shower throughout the morning of the 15th, and failing its brilliant apparition then, to repeat the watch on the morning of the 16th. The maximum may be displayed at any time between November 15, 0h. 30m. a.m. and November 16, 6h. 30m. a.m.

In England a November sky is cloudy on at least three nights out of four, and this year we shall have moonlight to consider as well, for our satellite will be nearly full, and must largely detract from the striking character of the display. Should the meteors appear on the morning of the 15th, they might, however, be seen on a dark sky, for the moon will set about $2\frac{1}{2}$ hours before sunrise. The Leonids are fine meteors; a large proportion of them are as bright as 1st mag. stars, and, notwithstanding moonlight, will create a conspicuous effect if they return in great numbers. On the occasion of the last grand display on the morning of November 14, 1866, the writer was much struck with the number of tolerably bright meteors, and observed several which were many times brighter than Venus at her best. These Leonid fireballs gave lightning-like flashes, and left short green streaks, enduring for five, ten, fifteen minutes, and even more. The approaching display will be sure to supply a few of these splendid objects.

At every station where the weather enables the shower to be successfully witnessed, certain features ought to be particularly recorded. The meteors should be counted, and the time of maximum ascertained. It will be useful also to determine the hourly rate of apparition by noting at certain regular intervals the number which appear. By counting during short intervals and continuing the work for several hours, the rise and fall of the display as well as the number per minute at and near the time of maximum might possibly be obtained. In the event of an exceedingly abundant display, similar to that seen in America in 1833, the observer may feel bewildered and find it impossible to record the exact numbers. In such a case the figures should be estimated as carefully as possible.

Another feature will be to preserve a description of the time, brightness and apparent paths of any specially fine Leonids that may be visible. The paths should be marked on a celestial globe or suitable star-map, and the Right Ascension and Declination of their beginning and end points registered in a book properly ruled for the purpose. The length, duration and possible drifting of the luminous streak, left by every bright meteor, should also receive attention. Near the time of maximum, however, these details may be disregarded, as it will be necessary for the observer to concentrate his efforts to fixing the time of the maximum and strength of the display. A table with writing material and a lamp should be at hand so that numbers and notes can be hurriedly recorded by the observer almost without diverting his attention from the heavens. With more than one observer the various aspects of a meteoric shower can be fully recorded, but it is impossible to suppose that one person can watch its progress and record all the details presented.

Observers need not specially record the meteors with the main object of fixing the centre of radiation. We have already obtained a great number of eye-estimates of this position, and these must be put aside for the more accurate values obtainable by photography. No doubt the latter method will be extensively brought into requisition, though the bright moonlight will afford


a serious hindrance on the present occasion. The Leonids begin to fall as early as November 7, and the shower is sustained over a fortnight. It will be very important to look for the meteors of this stream between about November 7-11, and record the paths of those visible with a view to definitely ascertaining the position of the radiant. At this early period of the shower's activity it is not probable that the photographic method will be appealed to. It is to be hoped that all regular meteoric observers will follow the progress of the shower with close attention during the second week of November in this year, for the questions as to the date of commencement of the shower and as to whether the radiant is a shifting or stationary one are very interesting features requiring settlement.

W. F. DENNING.

## *NOTES.*

COLONEL J. W. OTTLEY, C.I.E., has been appointed president of the Royal Indian Engineering College, Coopers Hill, in the place of Colonel Pennycuick, C.S.I., resigned.

THE Committee of the British Association Table at the Naples Zoological Station announce that the Table is fully occupied until the middle of April next, but that applications for its occupancy from then until the end of August 1900, should be sent at once to the Hon. Secretary of the Committee, Prof. Howes, F.R.S., at the Royal College of Science, South Kensington. Mr. Kyle will occupy the table from now until Christmas, when he will be succeeded by Mr. M. D. Hill, who will continue investigations on the reproduction processes of Crustacea, and in March Prof. Herdman will go out and devote a month to the study of the Tunicata of the Bay.

THE Harveian Oration was delivered at the Royal College of Physicians by Dr. J. Vivian Poore on Wednesday last.

AN address will be given to the North-west London Chemical Society, on October 24, by Dr. Lauder Brunton, F.R.S., who will take as his subject "Biliousness and Gall Stones." On November 2, Sir J. Burdon-Sanderson will deliver an introductory address to the Middlesex Hospital Medical Society. To this all past and present students of the hospital are invited.

A TELEGRAM from Amsterdam, dated October 12, states that a violent earthquake has occurred in the south side of the Island of Ceram, in the Dutch East Indies, causing the death of some thousands of persons and the complete destruction of the town of Amhei. Details, however, are wanting.

AT a meeting of the Finance Committee of the Lincolnshire County Committee, held on the 13th inst., it was resolved that the County Committee be recommended to give their consent to the erection, within the grounds of Lincoln Castle, of an observatory for the preservation and use of certain astronomical instruments offered to the county by the executors of the late Canon Cross, of Appleby. The recommendation was made that the committee's consent should be given subject to the condition that the buildings shall not be commenced until sufficient funds have been raised for their erection and the future maintenance of the instruments. It is proposed to raise the funds by public subscription. We trust there will be a hearty response to the appeal that is to be issued.

AT a meeting of the Council of the London Mathematical Society it was resolved that the president (Lord Kelvin), the three vice-presidents, the treasurer, and the two secretaries should be nominated for the same offices at the annual meeting on November 9 next. Of the other members, Messrs. W. H. H. Hudson, D. B. Mair, and W. D. Niven, C.B., retire from office, and Messrs. W. Burnside, H. M. Macdonald and E. T. Whittaker were nominated to fill the vacancies. The Council also empowered the secretaries to publish an "Index" to the first thirty volumes of the *Proceedings*, on the lines of the similar index to the first fifty volumes of the *Mathematische Annalen*. Mr. Tucker was further authorised to draw up a complete list of members from the foundation of the Society in 1865.

THE Council of the Royal Photographic Society have decided to institute a series of monthly meetings, extending from November to April, to be especially devoted to illustrated lantern lectures. The meetings will be held on the first Tuesday in the month, and the first will take place on November 7.

THE second Traill-Taylor Memorial Lecture will be delivered on November 14 at the rooms of the Royal Photographic Society by Major-General Waterhouse, who will take as his subject "The Teachings of the Daguerreotype."

THE third International Congress of Photography is to be held in Paris from July 23 to July 28, 1900. Its purpose will be to re-examine decisions arrived at by the two last Congresses on problems before the Society, and to see if such are capable of further improvement or perfection. To inquire into the various new photographic questions arising since the last meeting. Practical demonstrations of working methods, lectures on special subjects, and visits to scientific and industrial institutions also form part of the programme. Those intending to be present are requested to address the General Secretary, M. S. Pector, 9 Rue Lincoln, Paris.

THE magnetic survey of Maryland has now been practically completed, the distribution of stations being such that on the average there is one station for every hundred square miles. The expenses of the work, with the exception of this year, have been entirely borne by the Maryland Geological Survey.

A SCIENTIFIC and commercial mission, under the direction of M. Ernest Milliau, Director of the Laboratory of Technical Experiments in connection with the Ministry of Agriculture, Paris, has been sent to Russia and Roumania with the object of taking measures for facilitating and extending business relations with those countries, especially with regard to the exportation of olive oils.

A BACTERIOLOGICAL institute has recently been established at Vladivostok, and a similar institute is shortly to be opened at Merv in Central Asia.

OWING to the prevalence of enteric fever in Natal, every man ordered for military service in that Colony has, says the *Lancet*, been given the option of being inoculated with anti-typhoid serum, and 70 per cent. of the troops have accepted the offer.

THE late Prof. O. C. Marsh's executors are about to sell his valuable collection of orchids, objects of art, antiquities, &c., for the benefit of the Yale University.

ACCORDING to the *Scientific American*, Japan is to send out an Arctic Expedition. The Japanese Government wishes, says our contemporary, to develop in the Japanese the spirit of adventure and discovery which has rendered the English nation so powerful.

THE New York Zoological Park, situated in Bronx Park, is to be opened to the public this month. The *Scientific American* states that the specimens which will be ready for public inspection will form but a small part of the exhibit, and that these will be very interesting.

THE return, after an absence of two years, of Mr. A. J. Stone, of New York, is announced. Mr. Stone has been travelling in the Arctic regions during the time mentioned, studying the geographical distribution of animals. It is reported that during five months of travel last winter he covered 3000 miles of coast and mountain entirely above the Arctic circle.

*Science* announces the return from Manila of the Johns Hopkins University Commission, which, under the direction of Dr. S. Flexner, has spent the past summer in studying tropical diseases.

THE death is announced, from Vienna, of Dr. Oscar Baumann, who had acquired some reputation as an African explorer. In 1885 Dr. Baumann joined the Austrian Congo expedition, subsequently visiting the island of Fernando Po, the Cameroons, and parts of East Africa. Other expeditions followed, in one of which he fell into the hands of hostile Arabs, and was only released on the payment of a ransom. He was entrusted with

the command of an expedition fitted out in 1889 by a German anti-slavery association. In the following year he explored the Usambara, and made preliminary observations for the purpose of tracing a projected railway in that region. In addition to a map of the Congo and numerous contributions to the reports of the Geographical Society of Vienna, Dr. Baumann published three books dealing with his travels and observations in Fernando Po and Usambara and with the rising in German East Africa.

We regret to notice the death of Dr. J. W. Hicks, the Bishop of Bloemfontein, which has just taken place. The late Bishop was an earnest student of science, and was at one time a demonstrator in chemistry in the University of Cambridge, and published a text-book on inorganic chemistry. He was also a fully qualified medical man, having been made an M.D. in 1864, and an M.R.C.P. in 1865.

The death has occurred, at Adirondacks, New York, of Mr. Hamilton Y. Castner, well known for his work in connection with the manufacture of aluminium and the establishment on a manufacturing scale of a process for the electrolytic production of alkali and bleaching powder from common salt.

The *National Geographic Magazine* states that various sites within a radius of twenty-five miles of Washington are being examined by parties under Dr. Bauer's direction for the determination of the best location for the Coast and Geodetic Survey Observatory. The examinations thus far made have disclosed some interesting regional disturbances, especially in the vicinity of Gaithersburg. In order to determine what influence such regional disturbances have upon the variations of the earth's magnetism, such as, for example, the diurnal variation or the secular variation, it is proposed to mount a sensitive Eschenhagen dedinetograph at Gaithersburg, with the aid of which the variations of the most sensitive of the magnetic elements—the declination—will be continuously and automatically recorded.

The British Fire Prevention Committee made a series of fire tests yesterday at their testing station as we went to press. The tests on this occasion were with a concrete floor, an iron safe, and two doors of wood. We are glad to see that the committee are continuing their valuable work in so energetic a manner. Valuable results may be expected to accrue from the experiments made by the committee from time to time.

A monument erected to the memory of Johannes Müller was unveiled at Coblentz on October 7. Prof. Virchow, who was the principal speaker at the ceremony, said in the course of his remarks that Müller was a biologist, a naturalist whose aim was the study of life itself in its universality. He was the first to use the microscope in researches on living beings, the first to disclose the fauna of the seas. His example inspired the deep-sea researches of to-day. Müller's method was observation; he put things into the right positions for exhibiting their action, and then registered his observations. At the time of Müller's youth it was believed that from inanimate nature, from atoms, from matter, or substance, new combinations might form themselves, which finally might lead to the generation of living organic forms, that, in short, plants and men might be evolved from dust. In modern times this had been named spontaneous generation. Johannes Müller warned against such hypothetic conclusions. He said: "We cannot generate living substance, and as long as we cannot do so, as long as we have no proof, we must put these theories aside"; and (said Prof. Virchow) that is the standpoint of resignation, of submission, that is the true position for a naturalist, such as Muller was. On the occasion of the unveiling of the monument, Muller's daughter presented to the State Library fourteen volumes of drawings, containing upwards of nine hundred zoological sketches made by her father in the years 1850–1854 in various countries.

The Indian correspondent of the *Lancet* states that new regulations have been made with reference to persons sending or taking from place to place in India cultures or other articles known or believed to contain the living germs of plague. No person who is not a commissioned medical officer, a military assistant surgeon, or a medical practitioner in possession of a qualification not lower than that of L.M.S. of the University of Calcutta, Madras or Bombay shall without the special permission of the Governor-General in Council or a local government take in his private possession from one place to another any cultures or other articles which he knows or believes to contain the living germ of plague. No such culture shall be sent from one place to another unless it is securely packed in a hermetically closed tin of adequate strength, placed in a strong outer box of wood or tin, with a layer of at least three-quarters of an inch of raw cotton wool between the inner and outer case, the outer case being enclosed in a stout cloth, securely fastened and sealed, and labelled with such distinguishing inscription as will suffice to make immediately manifest the nature of the contents.

According to a recently issued consular report, a new process for the production of ammonia has recently been discovered in Germany. The process is said to be at present an expensive one, but this difficulty will, it is thought, be overcome.

An American paper, the *Pharmaceutical Era*, has published an article by Mr. H. M. Whelpley, of St. Louis, in which particulars are given as to the use of the metric system in American physicians' prescriptions. It appears from the article that out of 1,008,500 prescriptions examined, only 6 per cent. were in the metric system. The information was obtained from apothecaries in forty-two States and territories.

A short article in the current number of the *National Geographic Magazine* sums up in brief the main results of Lieut. Peary's explorations in 1898–99, from which we extract the following information:—In the south Peary discovered that the so-called Hayes Sound, north-west of Cape Sabine, is only an inlet or bay. It was supposed by many that it extended through to the Arctic Ocean west of Ellesmere Land, and separated that country from Grinnell Land on the north. It now proved that these regions are one and the same land. He also travelled west across the northern part of Ellesmere Land, which has never before been penetrated for any distance, and visited its west coast, joining his survey of the shoreline with the short bit of the coast further north, which Lockwood, of the Greely Expedition, discovered in May 1883. This is the first time that any part of this coast has been seen south of the inlet visited by Lockwood. In his various sledge journeys up the channel from the *Windward's* position, Peary skirted the east coasts of Grinnell Land and Grant Land for a distance of about 250 miles, rectifying the mapping of this shore-line in some respects, and particularly the surveys of a number of indentations. The most northern point reached by Peary was Cape Beechey, about 82° N. latitude. No effort to push northward has been made this summer, and Peary's winter camp has been established on the Greenland side of Smith Sound, several miles further south than his quarters of a year ago.

Prof. Koch has published his first report on his study of malaria in Italy in the *Deutsche Medicinische Wochenschrift*. In all the cases of malaria examined by Prof. Koch and his assistants the parasite of malaria was found in the blood. Apart from the blood of human beings, the parasites occurred only in some species of mosquitoes which were met with only in the summer. The mosquitoes convey the malaria germs

from one human being to another: the infection is especially maintained and propagated by the relapsing cases which continue all the year round and form the link between one fever season and the next, so that the mosquitoes in the beginning of summer always find germs. If no relapse occurred in any of the cases of malaria in any given district the mosquitoes would find no germs in the beginning of summer, and malaria would become extinct there. Prof. Koch succeeded in recognising certain species of mosquitoes in the dwellings of the population; this was the more important, as the mosquitoes of this district did not usually bite during the day but only during the night. The inhabitants therefore became infected at night within their dwellings. In seven cases parasites of malaria were discovered in insects, especially in *Anopheles maculipennis*. In many dwellings, however, where patients had contracted malaria, anopheles was not present, but another insect, *Culex pipiens*, was hardly ever absent. Prof. Koch ascertained that the so-called æstivo-autumnal fevers were identical with tropical malaria.

*Industries and Iron* gives particulars of an electric fog-alarm which, it is reported, has been invented by a Canadian electrical engineer. The description is as follows:—A naphtha engine supplies the motive power to a dynamo that furnishes the electric current, by means of which three pairs of electromagnets operate half a dozen clappers that strike against a large gong with a frequency of about 36,000 strokes a minute, producing an almost continuous sound. Its effectiveness is enhanced by a mechanism somewhat on the principle of a megaphone, by means of which the sound is not only intensified but thrown in the required direction. A model of this fog-alarm was not long ago tested at Ottawa, and although it was comparatively a small affair, its sound was easily heard a distance of two miles. The sound of the completed machine will be (it is thought) distinguishable at a distance of fifteen miles.

As an example of the interest that is taken in anthropology on the continent, we call attention to the publication of the free courses of lectures delivered by Prof. E. Morselli at Turin and Genoa. The title of the publication is "Antropologia Generale: Lezioni su l'Uomo secondo la Teoria dell' Evoluzione." When will it be possible for the English public to hear systematic lectures on anthropology of any kind, free or otherwise? Prof. Morselli puts his subject clearly, judging from the portions only of the two lectures that we have received.

ANTHROPOLOGISTS who more particularly study European ethnology should be very grateful to Dr. William Z. Ripley, of Boston, for the "Selected Bibliography of the Anthropology and Ethnology of Europe" that has just been issued by the Trustees of the Public Library of Boston, Mass. The list contains nearly two thousand titles in nearly all the languages of Europe; the Slavic writers are very well represented. The authors are arranged in alphabetical order, and their several publications are cited chronologically; this is followed by a subject-index. The labour of compiling this bibliography must have been immense, but Dr. Ripley will have the satisfaction of feeling that he has supplied his colleagues with a valuable and indispensable tool.

AMONG the most useful instruments employed in Italy for the registration of earthquake movements are the microseismographs, designed by Prof. Vicentini and modified by Dr. Pacher, which have been erected in the Physical Institute of the University of Padua. Hitherto the records have been published at irregular intervals in the *Atti* of the R. Istituto Veneto di Scienze, &c., but it is now arranged that they shall appear systematically and ultimately form an appendix to the yearly volume. The first number, recently issued, contains the register from January 1 to March 12 of the present year, and also notes with regard to the arrangement of the different instruments.

THE tin trade of prehistoric Europe is a subject of considerable interest and importance. Very recently Salomon Reinach (*l'Anthropologie*, x., 1899, p. 397) has again attacked the problem and has arrived at the following conclusions. A thousand years B.C. there was an almost exclusively overland trade between the British Islands and Thrace and Macedonia. The relations between Britain, Northern Europe and Western Asia have been proved by archæology, by the diffusion of tin, amber, spiral ornaments and the types of bronze arms and utensils. Thus it is not surprising that Homeric Greece about 800 B.C. knew not only the Celtic name of the Cassiterides, but the phenomenon of the short nights of the north of Britain. The overland tin was brought to the Ægean, if not by Greeks, then by Barbarians. These Barbarians, accurately knowing the country from which the tin came, sought a marine route in order to retain this precious trade in their own hands. This was rendered more feasible by the invention of the anchor by the legendary Midas of Phrygia, for then ships could ride with safety in the open. Reinach considers that it was he who first brought tin and lead to Greece by sea by the north-west route, and it was only later that the Phœnicians got the tin trade into their hands. The English Leake, Hamilton and Ramsay have rediscovered Phrygia, but twenty-seven centuries ago the Phrygians discovered England.

THE *Bulletin de la Société Astronomique de France* for October contains several interesting meteorological articles. M. E. Touchet contributes an illustrated article on the storms of August and September 1899, showing some excellent lightning pictures. He gives special attention to the type of lightning which is apparently unaccompanied by thunder. M. A. Souleyre, writing on the "distribution of rain on the earth," summarises the interaction of the various air-currents and the barometric variations connected with rainfall. MM. V. Farquon and F. A. Mavrogordato give short accounts of their observations of the "green ray" on the Alps and at Smyrna respectively.

THE October number of the *Journal of Conchology* contains an interesting paper by Messrs. Melvill and Standen on the cowries of the *caput-serpentis* group. In that group are included not only species with a dark peripheral area and a spotted centre, like the typical *Cypraea caput-serpentis*, *C. mauritiana*, and *C. arabica*, but likewise the ring cowry (*C. annulus*) and the familiar money cowry (*C. moneta*). The two latter, as many of our readers are aware, are white; the yellow ring from which the second of the two derives its name marking the line of division between the spotted central and the dark peripheral area of the serpent-head cowry (*C. caput-serpentis*). If proof were necessary to demonstrate that this is the true explanation of the coloration of the two species, it is afforded by the discovery of a white example of a variety of *caput-serpentis*, in which the dorsal spots are still faintly visible. It has been recently stated by another writer that "from the ring cowry may easily be derived the money cowry, in which the ring has all but disappeared, while the marginal area has developed a series of rugosities, apparently connected with the filaments on the margins of the mantle lobes." And Messrs. Melville and Standen now come to the conclusion that these two cowries are really nothing more than races of a single species, for which the name *C. moneta* should be retained.

THE last number of the *Transactions* of the Norfolk and Norwich Naturalists' Society bears ample testimony to the maintenance of the taste for natural history and botany which has always been so characteristic of that favoured county. As is only proper, the great bulk of the papers refer to local

subjects, while a few, like Mr. Warde Fowler's notes on the birds of the Somme Valley, supplement the history of native species in other lands, the remainder having no particular connection with the county. Especial interest attaches to Mr. S. F. Harmer's note on the occurrence of the well-shrimp (*Niphargus*) near Norwich; and likewise to Mr. J. H. Gurney's account of the distribution of the Bearded Tit. Various specialists bring the lists of the Norfolk fauna and flora up to date. And those who study economic zoology will be interested in the notes of Mr. G. H. Harris on the herring fishery of 1898. So far as the Yarmouth boats were concerned, this appears to have been a practical failure. It was not that the catch was always bad; but, whatever the catch, prices were forced down by the poor quality of the fish. And this is mainly attributed to the mild season, herrings being never of high quality in warm weather.

AMONG recent papers in the *Journal of Applied Microscopy*, Mr. Charles J. Chamberlain's series of articles on "Methods in Plant Histology" will be useful to teachers and students of practical botany. The last articles contain illustrated accounts of the principal families of algæ with methods of preparing for observation. One of these methods is, however, capable of improvement. To place specimens in a 10 per cent. solution of glycerine, and allow the solution to evaporate till it is of the consistency of pure glycerine would be unnecessarily tedious. It is simpler and equally efficacious to place the specimens in water in a small receptacle of parchment paper, and float the latter on glycerine, the change of density taking place through the paper by osmosis instead of by evaporation.

A VERY clear photographic group of official members of the recent Dover meeting of the British Association, together with members of the French Association and the Belgian Geological Society, has been sent to us by the photographers, Messrs. Lambert Weston and Sons, of Dover, from whom copies may be obtained. In the majority of instances the individuals portrayed can easily be identified.

THE additions to the Zoological Society's Gardens during the past week include a Rhesus Monkey (*Macacus rhesus*, ♀) from India, presented by Mrs. J. Adams; a Black-faced Spider Monkey (*Ateles ater*) from Eastern Peru, presented by Mr. Claude P. Landi; a Common Chameleon (*Chamaeleon vulgaris*) from North Africa, presented by Mr. A. H. Ryan; a Red-cheeked Souslik (*Spermophilus erythrogenys*), four Eversmann's Sousliks (*Spermophilus altaicus*), four Altai Sousliks (*Spermophilus mugosaricus*) from Western Siberia, a Common Seal (*Phoca vitulina*), British, a Common Cormorant (*Phalacrocorax carbo*, var.), European, an Emu (*Dromaeus novae-hollandiae*), three Long-necked Chelodines (*Chelodina longicollis*) from Australia, an Uvæan Parrakeet (*Nymphicus uvaeensis*) from the Island of Uvea, a Rosy Parrakeet (*Palaeornis rosa*) from Burmah, a Four-lined Tree-frog (*Polypedates quadrilineatus*) from the East Indies, a Westerman's Eclectus (*Eclectus westermani*) from Moluccas, deposited; six Glossy Ibises (*Plegadis falcinellus*), bred in the Gardens.

## OUR ASTRONOMICAL COLUMN.

COMET GIACOBINI (1899 *e*).

*Ephemeris for* 12*h*. *Berlin Mean Time*.

| 1899. | R.A. h. m. s. | Decl. ° ′ | Br. |
|---|---|---|---|
| Oct. 19 | 16 57 8 | +0 46·4 | |
| 21 | 17 0 3 | 1 19·0 | 0·71 |
| 23 | 2 59 | 1 51·2 | |
| 25 | 5 55 | 2 23·0 | 0·66 |
| 27 | 8 52 | 2 54·5 | |
| 29 | 17 11 49 | +3 25·6 | 0·62 |

A circular from the Centralstelle at Kiel informs us that owing to an error in one of the published observations, there is some doubt as to the correct elements of this comet. In consequence of this the above ephemeris may not be quite accurate, but, as according to the latest observation recorded, it is less than one minute in R.A. and two minutes in Decl. in error, it will be useful for searching purposes. The comet is travelling to the north-east through Ophiuchus, a little south of the second mag. star α Ophiuchi.

HOLMES' COMET (1899 *d*).

*Ephemeris for* 12*h*. *Greenwich Mean Time*.

| 1899. | R.A. h. m. s. | Decl. ° ′ ″ |
|---|---|---|
| Oct. 19 | 2 53 1 | +48 49 51 |
| 20 | 51 57 | 48 54 5 |
| 21 | 50 51 | 48 57 56 |
| 22 | 49 44 | 49 1 25 |
| 23 | 48 36 | 49 4 30 |
| 24 | 47 27 | 49 7 13 |
| 25 | 46 17 | 49 9 33 |
| 26 | 2 45 7 | +49 11 29 |

This comet is now in the middle of Perseus, being nearly on the line joining β and γ Persei, about two-thirds of their distance from the former.

OPPOSITION OF JUPITER, 1899.—*Astronomische Nachrichten* (Bd. 150, No. 3596) contains the results of several observers' work on the planet during the last opposition of 1899 April 25. M. J. Comas Solá, of the Catala Observatory, gives a planispheric map of the markings observed by him with a Mailhat objective of 22 cm. aperture, from February 18 to July 8. Tables are given showing the various rotation periods obtained from observations of spots in different zones, a summary of which is as follows:—

Mean velocity of spots on south border of equatorial zone ... } = 9h. 50m. 23·35s. (from 22 spots)
Mean velocity of spots on north border of equatorial zone ... } = 9h. 50m. 15·25s. (from 9 spots)
∴ mean equatorial velocity ... = 9h. 50m. 20·76s.

This, compared with Denning's mean velocity for 1898, 9h. 50m. 23·6s., would indicate an acceleration since the spring of 1897.

Measures of the "red spot" gave a period of 9h. 55m. 41·85s.

Herr Ph. Fauth also gives a planispheric drawing showing the details observed from May 30 to June 13, with a Pauly objective of 17·8 cm. aperture.

Mr. A. Stanley Williams, of Brighton, gives his observations of the "red spot" made during the period March 13 to June 16 with a 6½-inch reflector. The period found is given as 9h. 55m. 42·65s. from 229 rotations (March 13 to June 16). He finds the spot to be a little shorter now than it was in 1887 (31°·7 instead of 34°·7).

LAW CONNECTING MOTIONS IN PLANETARY SYSTEM.—M. Ch. V. Zenger, of Prague, has recently put forward the results of work he has been engaged on for some years past, and a part dealing with the relations existing between the "time of a planet's revolution" and its position in the solar system appears in the *Bulletin de la Soc. Ast. de France*, October 1899, pp. 431–434. He finds that the orbital movements of the planets and also of some periodical comets have a simple law connecting them with the time of the sun's rotation. If "*r*" is the time of *rotation* of the central controlling body, then "R," the time of *orbital revolution* of the planet, is given by the relation $R = n\frac{r}{2}$; where "*n*" is a whole integer, different for each body.

Taking Faye's value for the solar rotation = 25·2 days, $\frac{r}{2}$ = 12·6 days, and the author gives the following data:—

| | Mercury | Venus | Earth | Eros | Mars | Jupiter | Saturn | Uranus | Neptune |
|---|---|---|---|---|---|---|---|---|---|
| N = | 7 | 18 | 29 | 51 | 54 | 344 | 854 | 2436 | 4776 |
| R | 88·2d. | 226·8d. | 365·4 | 642·6 | 680·4 | 4344·4 | 10765·4 | 30693·6 | 60177·6. |

Between the earth and Eros, the author mentions the possible existence of a hitherto unknown planet for which $n = 40$, and the period of revolution of which would therefore be about 500·4 days.

Several tables are also given showing the conformation of the satellites of the various planets to a similar relation, and the author considers the whole as helping to confirm his electrical theory of the solar system.

## *ON THE CHARACTERISTICS OF A UNIVERSITY.*

THE beginning of a new academical year is one of those periods of sudden change which must leave its mark for good or bad on every university and college in the land. Well-known faces of those who have been prominent in work or sport are missing. New recruits are taking, with halting steps, their first lessons in the drill which is soon to become so familiar. In a few days they will be undergoing their "baptism of fire" in struggles wider and keener than any in which they have yet been engaged; and in which each, according as he bears himself, must either add to or diminish, be it by ever so little, the position which his college holds in the eyes of the world. At such a period we naturally halt for a moment, and before we face the future, cast our eyes backward.

One conspicuous change has taken place in the past session. Sir John Donnelly has retired from the permanent headship of the Department of Science and Art, and has been replaced under new conditions by Captain Abney. It would be contrary to all the wholesome traditions which govern the conduct of servants of the Crown if I attempted to discuss these important events. I will therefore only say, in words which are colder than my feelings, that we wish our late chief long life, health and happiness in the rest to which the strenuous service of many years has entitled him; and that we welcome as his successor one who is not only a distinguished public servant, but a distinguished man of science.

Two losses, I must mention, of men who, though unknown to each other, were both known to many of us. Both had, in different ways, deserved well of the college. Both have passed away since the last term ended. But though alike in these respects, their fates were strangely different.

Sir Edward Frankland, for long Professor of Chemistry in this college, had touched the topmost rungs of the ladder of scientific fame. The Royal Society bestowed upon him its highest honour—the Copley Medal. The French Academy of Sciences had given him the highest distinction it can confer upon one who is not a Frenchman, by placing his name on the select list of eight foreign members. Happy in the work of his life, he was no less happy in the opportunity of death. The end came, without long previous suffering or slackening of mental power, in the midst of the holiday haunts which must, as life faded, have recalled some of its brightest hours. The Royal College of Science will remember him as one of the earliest and the most distinguished members of its staff.

The other name I would mention is that of one who was recently numbered among our students. Ernest Harrison gained the Associateship in Physics a year ago, taking the first place in the final examination. He had previously won a scholarship at Trinity College, Cambridge. His career here gave reason to believe that his future would be successful; but his early death has quenched the hopes of his teachers and his friends. The fact that he has died a very young and therefore a comparatively unknown man, makes it all the more the sad duty of us who knew him to record the promise of his youth.

Turning from the past, the changes which loom largest in the immediate future are the erection of the new buildings and the creation of what will in effect be a new university. Of the former I will only say that they will be on a scale not unworthy of the largest city in the world; but the establishment of a teaching university must be so pregnant with good or ill that I shall offer no apology for returning, by a somewhat different line of approach, to a subject on which Sir Norman Lockyer dwelt last year.

Let us then, in the first place, ask what are the chief notes which distinguish from all others the mode of preparation for the work of life which should be characteristic of a university.

Put shortly, I take it that two notes are predominant above all the rest. The first is that a university is a place where education is combined with the advancement of knowledge; the second, that the teaching of a university is based upon the principle that knowledge is desirable for the influence which knowledge and the search for knowledge exert upon ourselves, and not merely for the power which they confer of improving our external surroundings. The first of these characteristics distinguishes the university from a school; the second from a workshop or a college with purely technical aims.

[1] [illegible] delivered at the opening of the Royal College of Science, [illegible] by Prof. Rucker, F.R.S.

I shall say very little on the fact, which no one will dispute, that it is the duty of a university to advance knowledge. To do us justice, we of the Royal College of Science have not been unmindful of this duty. It is impossible to speak of the present or more recent past, but I may be permitted to say that a college which has numbered Huxley, Stokes and Frankland among the members of its staff will have forgotten all the teaching of its earlier history if it ever fails to satisfy the first test of fitness for a university status. I only hope that the schemes which are being mooted for founding new research professorships do not veil an attempt to place in other hands that part of the work of the London colleges which is specially characteristic of a university. London needs a multiplication of teachers on a sufficiently large scale to enable them to conduct both teaching and research, not the creation of separate castes of teachers and investigators.

Let me turn next to the second note of a university, viz. that it insists that knowledge has a value apart from the commercial or utilitarian objects for which it may be used.

In this capacity a university maintains, or ought to maintain, a constant protest against the view that a man and his knowledge are to be measured by their money value alone. This view was never more clearly expressed than by Colonel Diver, according to whom the aristocracy of New York consisted "of intelligence, sir, . . . of intelligence and virtue. And of their necessary consequence in this republic—dollars, sir." It is needless to deny that "dollars" are often the reward o. intelligence and virtue. In the case of most men, the search after them must necessarily be a matter of importance; but this fact is too often used to make preparation for the business side of life the only or the chief end of education.

As I was writing these lines a number of *Literature* reached me, in which there is a review of a work by an assistant professor of the history and art of teaching in the Harvard University. This gentleman proposes to have "commercial courses" in all the schools. The purpose of these courses is to be, not merely "to train a youth to an appreciation of the functions of business and business practice in our modern life," and not merely to "inform him as to the history of industry and trade," but also to "awaken in him a profound interest in business as such," and to "train him to keep his eyes open to business possibilities."

Before I have done you will understand my reasons for agreeing with the reviewer that this is a "hideous educational programme." For the moment I will content myself with saying that it is based upon a one-sided view of life. There can be no question but that the business element is important, but a university is a corrective to the tendency to regard money as the only standard of value. This it does by inviting us to study and to care for things which we must admit are important and beautiful, but which we may not be able to convert into coin.

But, you may ask, if this is so, will not the admission o. technical colleges such as is, in part, our own, be inconsistent with your idea of a university?

To this I answer that, while it is possible that the desire to master the practical applications of knowledge might crush the desire to know things which are worthy to be known though not of immediate commercial advantage, the men who are managing the best technical colleges are aiming at leavening the technicalities of a profession with the love of knowledge. Example will illustrate what I mean better than precept. The late Dr. Hopkinson was a successful engineer, sought after to superintend great undertakings. Busy in the office and the law courts, he nevertheless was always investigating the secrets of nature, and wrote his name large in the *Transactions* of the Royal Society. Many others, whom in this room I need not mention, are animated by the same spirit. I think, therefore, that the welcome which several of our universities have extended and are extending to such men and to their students is a legitimate recognition of the fact that they have effected a real extension of the boundaries of the region in which the love of knowledge for its own sake prevails. It would be a disaster if the spirit of business and commerce were to dominate a university. It will be a triumph if the love of science and the love of culture were spread from the technical college to the machine shop and the factory.

And this brings me to my next point, to another and more subtle question, in some respects similar to that we have been discussing.

In life there is a competition, not merely between commercial

and intellectual interests, but between different intellectual interests themselves; and a characteristic of a university education is that by some means or other it aims at conveying, not merely accurate knowledge on some one subject, but a healthy interest in all forms of mental effort. This wider range, this general cultivation, should distinguish the university scholar from him who has merely mastered the technicalities of a profession. A man may be a good lawyer or tradesman, he may have grasped a branch of pure science or succeeded in a scientific profession, and yet be careless and ignorant of all that does not bear upon the central interest of his life. The blending of expert and general knowledge, of professional skill in some one subject and of intelligent interest in others, is not to be accomplished by obeying formal rules, such as those which must be followed in producing a given chemical compound. Each one of us must decide for himself what particular combination represents for him the maximum of gain and the minimum of loss; but the true university as distinguished from the professional or technical school is for ever preaching that man is many-sided, that the light of heaven reaches him through many windows, and though to some of us the call may come to sacrifice all else to gain one supreme end, yet it is well to count the cost and to remember that the loss may outweigh the gain.

In speaking of sacrifice I am not now referring to the ordinary habits of industry and self-control which are essential to success in any physical or intellectual struggle. I am dealing rather with that sacrifice which is so often made without any sense of loss, the surrender of all effort to understand the appeal made by nature or art to one or other of our higher intellectual powers.

A man may be so interested in painting or in music that he loses all sense of the divine curiosity which impels the man of science as he strives to unravel the plan of the universe. The seeker after truth may allow the dry light of science to wither the sensibilities which can be touched by art alone. He may purchase the higher knowledge at the cost of the higher emotions.

Let us then consider for a few moments the principles which should direct our choice, and the help which a University of London can give us in choosing.

With regard to principles, it is impossible, as I have already said, to lay down any hard and fast rules. In this, as in so many other questions on which a practical decision must be made, two extreme courses are possible to follow, either of which is in most cases clearly wrong. I shall call before you a distinguished advocate of each, and allow them to plead in their own words.

The first policy may be called the policy of concentration, dear to the apostles of the gospel of self-help.

"The one prudence in life," says Emerson in his essay on Power, "the one prudence in life is concentration; the one evil is dissipation: and it makes no difference whether our dissipations are coarse or fine; property and its cares, friends, and a social habit, or politics, or music, or feasting. Everything is good which takes away one plaything and delusion more, and drives us home to add one stroke of faithful work. Friends, books, pictures, lower duties, talents, flatteries, hopes—all are distractions which cause oscillations in our giddy balloon, and make a good poise and a straight course impossible. You must elect your work; you shall take what your brain can, and drop all the rest. Only so can that amount of vital force accumulate which can make the step from knowing to doing. . . 'Tis a step out of a chalk circle of imbecility into fruitfulness."

And yet what counsel is this! To you the happiness or sorrows of your friends are to be mere distractions which make a straight course towards the conclusion of your own task impossible. Politics—that is the well-being of your country; books, the whole world of literature; music and pictures, all these are mere playthings and delusions, which you are to cast aside with all other childish things, and now that you are a man you are to care only for doing your own stroke of faithful work.

It is nothing to you that you are viewing with callous indifference the faithful work of others. "At sundry times and in divers manners" the noblest of our race have been striving to express the best that was in them by poetry and prose, by line and colour, by oratory and music. You are to care for none of these things. They are dissipations—not indeed of the coarsest kind—but dissipations none the less, dissipations which distract you from your own sustained and self-conscious endeavour to do something which may perhaps entitle you to rank among the meanest of those whose works you spurn. And then, when the work is done, the discovery made, the memoir published, what wonder if they in turn regard it with a disdain not less than your own? what wonder if Charles Lamb, along with Court Calendars, Directories, Draught Boards, bound and lettered on the back, and Almanacs, should place scientific treatises in his list of Biblia A-Biblia; or Books which are not Books?

Turn now to the other extreme policy, that which regards it as our wisdom to aim, not so much at one high end which can be attained only by an intense concentration, as at the "fruit of a quickened, multiplied consciousness."

No one has put the case in support of this philosophy more eloquently than Walter Pater in the celebrated conclusion to his "Studies in the History of the Renaissance."

The passage is too long to quote in full, but he tells us that the service of culture to the human spirit "is to startle it into a sharp and eager observation.

"Every moment some form grows perfect in hand or face; some tone on the hills or sea is choicer than the rest; some mood of passion or insight or intellectual excitement is irresistibly real or attractive for us—for that moment only.

"Not the fruit of experience, but experience itself is the end. A counted number of pulses only is given to us of a variegated, dramatic life. How may we see in them all that is to be seen by the finest senses? How can we pass most swiftly from point to point, and be present always at the focus where the greatest number of vital forces unite in their purest energy?

"To burn always with this hard gem-like flame, to maintain this ecstasy, is success in life. Failure is to form habits: for habit is relative to a stereotyped world; meantime it is only the roughness of the eye that makes any two persons, things, situations, seem alike.

"While all melts under our feet, we may well catch at any exquisite passion, or any contribution to knowledge, that seems by a lifted horizon to set the spirit free for a moment, or any stirring of the senses, strange dyes, strange flowers, and curious odours, or work of the artist's hands, or the face of one's friend.

"Not to discriminate every moment some passionate attitude in those about us, and in the brilliance of their gifts some tragic dividing of forces on their ways, is, on this short day of frost and sun, to sleep before evening."

Beautiful words! But as their music fades from the ear, as the brilliance of the "hard, gem-like flame" is quenched by the light of day, can we accept their teaching? Not to do but to feel, not to achieve but to enjoy, is the rule of life to be deduced logically from these premisses. If some great work is to be attempted, it is for the sake of the experience, for the joy of the effort and the success, and not for the sake of the work itself. Even "the enthusiasm of humanity" is classed by Pater among the "high passions," which are valuable chiefly for "the quickened sense of life" they impart; and beyond and above them all is placed art, not because it leads to a noble end, but because it professes "to give nothing but the highest quality to your moments as they pass, and simply for those moments' sake."

If the doctrine of concentration leads to ignorance of the work of others, the doctrine of the multiplication of states of consciousness leads to the neglect of what you yourself may do. Nay, more; it leads to the paradoxical result that you laud and magnify the achievements of those whom, nevertheless, you count as having failed in life, if their work, like most of the best work of the world, has been brought to the birth with bitter travail; and if, in the effort to achieve, they have sacrificed the joys to be found in "strange dyes, strange flowers, and curious odours."

If you have to choose one philosophy or the other, to adopt one rigid rule of life, I take it that the nobler among you would follow Emerson rather than Pater, would prefer to do "one stroke of faithful work" rather than to maintain a life long ecstasy. But this is not one of the cases in which no compromise is possible, in which we must vote "Yea" or "Nay," and must put aside wholly one teaching or the other. It may be a great thing to make the efforts and sacrifices which are required in adopting an extreme position, but it is a still higher achievement to maintain through life the intellectual balance necessary for the policy of the "golden mean."

I am not concerned to deny that radically different views

underlay the teaching of Emerson and Pater, but nothing is more certain than that neither Emerson nor Pater meant the passages I have read to be taken in the literal sense which might be ascribed to them. Even in the teaching of science it is sometimes necessary for the teacher to aim at being clear rather than correct; to force home the appreciation of the nature of some central truth by stating it as boldly as possible, and by sacrificing the pedantic exactitude which would insist that in its very first presentment it must be hedged about with every qualification and safeguard which long experience could suggest.

This was not the policy of the American teacher. Having set the mind in motion he left to its natural "after working" the discovery of qualifications and safeguards.

"Emerson," says Mr. John Morley, "has not worked out his answers to these eternal enigmas, for ever reproducing themselves in all ages, in such a form as to defy the logician's challenge. He never shrinks from inconsistent propositions. He was unsystematic on principle. 'He thought that truth has so many facets that the best we can do is to notice each in turn, without troubling ourselves whether they agree.'"

No better evidence of the truth of this remark could be adduced than Emerson's treatment of the relative importance of special knowledge and general culture. We have heard him on the one side. Let us listen to what he has to say on the other.

"He only is a well-made man who has a good determination. And the end of culture is not to destroy this. God forbid! but to train away all impediment and mixture, and leave nothing but pure power. Our student must have a style and determination, and be a master in his own specialty. But, having this, he must put it behind him. He must have a catholicity, a power to see with a free and disengaged look every object."

Nor by putting "behind him" did Emerson mean that the student was to devote all his earlier years to one form of intellectual effort: and that when this had brought him competence or fame, he might turn for relaxation to what he had hitherto neglected—to art or science or literature, as the case might be.

"Culture," he says elsewhere, "cannot begin too early. In talking with scholars I observe that they lost on ruder companions those years of boyhood which alone could give imaginative literature a religious and infinite quality in their esteem."

He who has pored too closely and too long over one study cannot in a moment cast aside the fetters which the years have woven round him, and rise up, like Samson, a terror to the Philistines. The intellectual sectarian cannot by a sudden act of will or process of conversion become the intellectual catholic. As well might he hope that the muscles which have been disused for years should suddenly rival the sturdy frame of the athlete, that the bent back should become straight, and the vision of the wearied eyes keen. Mental, like physical powers, are atrophied by disuse. The arts of seeing something of many things and all of one must be cultivated at the same time, or side by side.

And Pater, like Emerson, trusted to the intelligence of the reader not to mistake the strong presentment of one side of a question for a judicial decision on the whole case. So shocked was he when it was pointed out to him that his teaching might be taken too literally, that he actually suppressed the magnificent passages I have read to you lest his meaning should be misunderstood.

For each of us, then, the safest path lies somewhere between these limits, though thousands lead dull or unsuccessful lives because they shape their course perilously near to one or other of them. My object to-day is to warn you against the two extremes, not to attempt to lay down rules which shall point out the best course between them, rules which could not serve for all characters and dispositions alike. Do not forget that nothing considerable is achieved without concentration. Remember that he who holds himself free to cast aside every interest which does not directly bear on the central object of his life purchases this freedom "with a great price."

Let us next inquire what a university can do to guide the student in his choice. And here I may say at once that in my opinion the methods which have been officially adopted have been open to grave criticism; and that even if this were not so, the secondary are at least as important as the primary effects of a university training.

The direct official method of promoting general knowledge has been to insist that the candidate must pass an examination in several diverse subjects either before or during his passage through the university.

No objection can be raised to regulations which insist that a student before entering the university shall have acquired the elementary knowledge and have undergone the intellectual training which may enable him to undertake more difficult studies; but cultivation is not attained by mastering Latin and Greek up to the point at which they become useful engines for cultivation, and then throwing them aside for life. To change the metaphor, studies so treated are, in the words of Mr. John Morley, "superfluous roots in the mind, which are only planted that they may be presently cast out again with infinite distraction and waste."

Mistakes such as these are due to the fact that, though each subject of study when regarded as central is surrounded by others which are very different from itself, but which nevertheless prop and support it, these subsidiary subjects are (as a rule) not officially recognised in the examinations for a degree.

Every scientific man would agree that a student who can read French and German is better prepared for a scientific career than one who, with an equal knowledge of science, can read English only. Why not allow to the higher attainments greater weight? Again, there can be no doubt that a scientific essay or treatise written in good English tends more to the advancement of "natural knowledge" than if the facts and arguments are badly expressed. Why not recognise this fact, as the Department of Science and Art has now done, by giving credit in the Honour examinations for the style in which the essays of candidates are written?

By such steps we should, at all events, secure that the teacher of science who chooses to take some pains with the essays of his students, or who urges them to learn to read French and German easily, should not feel that his advice, however useful it might ultimately be, would damage rather than improve their chances of a high place in the examination for a degree in science. Thus, too, we should keep open in the student's mind avenues by which he might attain to some interest in language and literature for their own sakes.

I am well aware of the objections which might be raised to such a scheme; and though I do not myself attach great weight to them, I will now only insist that if they are valid that fact is an additional proof of the truth of a proposition, which I do not deny, viz. that it is not so much by directing the studies of each individual student, as by bringing together teachers and learners who are teaching and learning very different things, that, by a mental "law of exchanges," the interests of all are widened.

It is no doubt a weak point in a college such as ours that the range of instruction is limited to science and to some of its applications, and that thus you are all studying closely allied subjects. Union with other colleges in a university may help to remedy this defect. Meanwhile, all that can be done officially to promote general cultivation is small compared with what you can do for yourselves and for each other, and this because you are at liberty to embrace a wider range than any university would be justified in forcing upon you. Your success as specialists will largely depend upon your studies and your teachers. Your wider cultivation will chiefly be the work of your relaxations and your friends.

Do not misunderstand me. In general, a young man with no physical defect will and ought to take an interest and a part in athletics. In a great metropolis this is even more necessary than in the case of universities which, like Oxford, Cambridge, St. Andrews or Gottingen, are comparatively in the country.

I am proud to be the president of a Boat Club which this summer won a race in a Thames regatta. I have been treasurer of two scientific societies, and am glad to be now the treasurer of the United Football Clubs of the engineering departments of the London Colleges. I hope and believe that these are the germs from which the athletic clubs of the future university will spring. I hope and believe that the undergraduates of that university will not differ from all other groups of young Englishmen in that, while engaged in the cultivation of intellect and taste, they neglect the cultivation of thews and sinews. But if it be granted that college work and college sports must fill up much of the time of all of you, there are still spare but precious moments in which you cannot indeed master, but may ward off, complete ignorance of things which have little to do with your studies or your sports, but are none the less worth knowing and loving. You have college societies where such things are discussed

and debated. They are described in the excellent little pamphlet which has been put in every freshman's hand. You can at the least do what is in your power to attend and support them. You can take care that your undergraduate days do not pass without the great names of literature becoming more than names to you. Books can be had for the asking from public libraries, they can be bought for pence where they used to cost shillings. We owe to the generosity of Prof. Perry the nucleus of a college library containing books which are not scientific. He who now devotes to literary trash time which he might spend in learning something of one of the greatest literatures of the world has nobody but himself to thank if his reading vulgarises instead of refines him. Taste is educated only by tasting; and it rests with yourselves whether you will learn to appreciate the difference between the great masters of the pen and penny-a-liners, between the wit of a great humourist and the vulgarities of the funny corner of a second-rate newspaper.

A bicycle ride will be none the less enjoyable if you train yourself, not merely to travel far, but to take an interest in the sights and scenes through which you pass. For the sake of example, let me remind you that no country is so rich as England in the architecture of its village churches. It is no hard matter to learn to recognise the principal peculiarities of the architectural types which prevailed from the days of the Saxons to Sir Christopher Wren. The text-books are, I presume, to be found in the Art Library. But as soon as the elements of English church architecture are known, an old church ceases to be merely a picturesque object. It is an historical document which you yourself can read. You do not need the aid of the sexton to tell you which is the oldest part. You can make a good guess at when that aisle was added, or that window knocked in a wall obviously older than itself. A visit to a cathedral becomes an intellectual pleasure. Weariness at the drone of the verger as he recites his oft-repeated lesson is replaced by an alert desire to know if the authorities from whom he learnt it confirm or correct the rapid conclusions as to date or history to which you yourself have come.

I might multiply such examples. Nowhere in England can you so easily or so cheaply as in London hear and learn to appreciate the best music the world has produced.

The wet half holidays of an undergraduate's career well spent in the National Gallery would give you a familiarity with all the great schools of painting which few travellers attain.

Every day as you come to or leave your work you may pass through one of the greatest art collections in the world, and it depends upon you alone as to whether you shall or shall not learn anything from it.

Understand me clearly when I reiterate that I am laying down no rules. I have tried only to lay the problem before you. How to combine the proper care for pounds, shillings, and pence with the love of knowledge for its own sake; how best to balance your various studies; how to add to the concentration required for the mastery of a single subject the open eye and the refined taste which may lead you to appreciate arts which you cannot emulate, and things beautiful which you can neither copy nor produce; these are problems in which a university may help you, but can help you only if you are willing to help yourselves. I have to-day aimed at nothing more than at reminding you that each one of the mental forces we have discussed is essential to the equilibrium of intellectual life; that if you wilfully neglect any of them, or devote yourselves too exclusively to one, you will fall short, and, it may be, sadly short, of the ideal which the true university holds up to her sons.

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## *THE BRITISH ASSOCIATION.*

### SECTION K.

#### BOTANY.

OPENING ADDRESS BY SIR GEORGE KING, K.C.I.E., LL.D., F.R.S., PRESIDENT OF THE SECTION.

II.[1]

THE second period of our history begins with the arrival in India in 1848 of Sir (then Dr.) Joseph Hooker. This distinguished botanist came out in the suite of Lord Dalhousie, who had been appointed Governor-General of India. The province to the exploration of which Sir Joseph directed his chief attention was that of Sikkim in the Eastern Himalaya, the higher and inner ranges of which had never previously been visited by a botanist, for Griffith's explorations had been confined to the lower and outer spurs. The results of Sir Joseph's labours in Sikkim were enormous. Towards the end of his exploration of Sikkim he was joined by Dr. Thomas Thomson, and the two friends subsequently explored the Khasia Hills (one of the richest collecting grounds in the world), and also to some extent the districts of Sylhet, Cachar and Chittagong. Dr. Thomson subsequently amalgamated the collections made by himself in the Western Himalaya with those made in Sikkim by Sir Joseph individually, and by them both conjointly in Eastern India; and a distribution of the duplicates after the fashion of the Wallichian issue, and second only to it in importance, was subsequently made from Kew. The number of species thus issued amounted to from 6000 to 7000, and the individuals were much more numerous than those of the Wallichian collection. The immediate literary results of Sir Joseph Hooker's visit to Sikkim were (1) his superbly illustrated monograph of the new and magnificent species of *Rhododendron* which he had discovered; (2) a similar splendid volume illustrated by plates founded on drawings of certain other prominent plants of the Eastern Himalaya which had been made for Mr. Cathcart, a member of the Civil Service of India, and (3) his classic "Himalayan Journals"—a book which remains until this day the richest repertory of information concerning the botany, geography and anthropology of the Eastern Himalaya. A remoter result was the appearance in 1855 of the first volume of a "Flora Indica," projected by himself and his friend Dr. Thomson. The first half of this volume is occupied by a masterly introductory essay on Indian botany, of which it is hardly possible to overrate the importance. This remarkable essay contains by far the most important contribution to the physico-geographical botany of India that has ever been made, and it abounds in sagacious observations on the limitation of species and on hybridisation, besides containing much information on the history of Indian botanical collections and collectors. The taxonomic part of the book was cast in a large mould, and the descriptions were written in Latin. Unfortunately, the condition of Dr. Thomson's health and the pressure of Sir Joseph's official duties at Kew made it impossible that the book should be continued on the magnificent scale on which it had been conceived. After a period of about twelve years Sir Joseph, however, returned to the task of preparing, with the aid of other botanists, a Flora of the Indian Empire, conceived on a smaller scale and written in the English language. His proposals for this work were accepted and officially sanctioned by the Duke of Argyll while he was Secretary of State for India. The first part of this great work was published in 1872 and the last in 1897. In the execution of this great undertaking Sir Joseph had the assistance of Mr. C. B. Clarke, who elaborated various natural orders; of Mr. J. G. Baker, who worked out *Leguminosae* and *Scitamineae*, and of Sir W. Thiselton-Dyer, Messrs. A. W. Bennett, Anderson, Edgeworth, Hiern, Lawson, Maxwell Masters, Stapf and Gamble. The greater proportion, however, of the book is Sir Joseph's own work, and a noble monument it forms of his devotion and genius.

Since the date of Sir Joseph Hooker's visit to India, by far the most important botanical work done in India has been that of Mr. C. B. Clarke. Rather than attempt to give any appreciation of my own of Mr. Clarke's labours (which would be more or less of an impertinence), I may be allowed to quote from the preface to the concluding volume of the "Flora of British India" Sir Joseph's Hooker's estimate of them. Referring to all the collections received at Kew since the preparation of the "Flora" was begun, Sir Joseph writes: "The first in importance amongst them are Mr. C. B. Clarke's, whether for their extent, the knowledge and judgment with which the specimens were selected, ticketed, and preserved, and for the valuable observations which accompany them." Mr. Clarke has published numerous papers on Indian botanical subjects in the journals of the Linnean and other societies. He has issued as independent books monographs of Indian *Compositae* and *Cyrtandraceae*, the former in octavo, the latter in folio, and illustrated by many plates; and he is now engaged on his *opus maximum*, viz. a monograph of the *Cyperaceae*, not only of India, but of the whole world; and to the completion and publication of this every systematic botanist is looking forward with eager anxiety.

During this second half of the century, Dr. Thomas Anderson, who was for ten years superintendent of the Calcutta Garden, collected much; and he had just entered on what promised to be a brilliant career of botanical authorship when his life was cut short by disease of the liver, contracted during his labours to establish the cultivation in British India of the quinine-yielding species of cinchona. Dr. Anderson was also the earliest conservator of forests in Bengal. Sulpiz Kurz, for many years curator of the Calcutta Herbarium, also collected largely in Burma, and besides many excellent papers which he contributed to the *Journal* of the Asiatic Society of Bengal, he prepared for Government an excellent manual entitled the "Forest Flora of Burma." This was published in two volumes in 1877. Other collectors in Burma were Colonel Eyre (in Pegu), Mr. Burness (at Ava), and the Rev. Mr. Parish, to whom horticulturists are indebted for the introduction to Europe of the beautiful orchids of this rich province. And in this connection must be mentioned Mr. E. H. Man, C.I.E., who, although not himself a botanist, has given for many years past the greatest possible help in the botanical exploration of the Andaman and Nicobar groups of islands, our first knowledge of which was, by the way, derived from the collections made by the naturalists of the Austrian and Danish exploring expeditions. A large book on Burma, which contains a good deal of botany, was published by an American missionary named Mason, who resided for the greater part of his working life in that country. General Sir Henry Collett, who commanded a brigade during the last Burmese war, also made most interesting collections in that country, the novelties of which were described by himself in collaboration with Mr. W. Botting Hemsley, of the Kew Herbarium, in the Linnean Society's *Journal* some years ago. Sir Henry Collett also collected much in the Khasia and Naga hills, and in the portion of the North-western Himalaya of which Simla is the capital, and on these latter collections, together with the materials in Kew Herbarium, Sir Henry is now elaborating a local flora of Simla. The preparation of a local flora for an Indian district is an entirely new departure, and the publication of Sir Henry's book, which is to be well illustrated, is looked forward to with much interest. At rather an earlier period, Dr. Aitchieson was a diligent collector of the plants of the Punjab and of the North-western Frontier. Some results of his work are to be found in his "List of Punjab Plants," which was published in 1867, and in various papers which he contributed (some of them in conjunction with Mr. Hemsley) to the Linnean Society and to the Botanical Society of Edinburgh. In Dr. G. Henderson's book on Yarkand there are also descriptions of some plants of the extreme North western Himalaya and of Western Tibet. Mr. (now Sir George) Birdwood also made some contributions to the botany of the Bombay Presidency.

Five officers of the Indian Forest Department, viz. Dr. Lindsay Stewart, Colonel Beddome, Sir D. Brandis, and Messrs. Talbot and Gamble, have within the past thirty years made important contributions to the systematic botany of India. Dr.

[1] Continued from p. 584.

Stewart collected largely, and published in 1869 his "Punjab Plants," a book which gives a very imperfect impression of his acquirements as a botanist. Sir Dietrich Brandis issued in 1874 his admirably accurate "Forest Flora of the North-west Provinces of India," illustrated by seventy excellent plates. Between the years 1869 and 1873, Colonel Beddome issued his "Flora Sylvatica of the Madras Presidency," illustrated by numerous plates. He also published, between 1869 and 1874, a volume of descriptions and figures of new Indian plants, under the title "Icones Plantarum Indiæ Orientalis." Colonel Beddome is the only Indian botanist of note, except Griffith, Mr. C. B. Clarke and Mr. C. W. Hope, who has written much on Indian ferns. His two works, the "Ferns of Southern India" and the "Ferns of British India," published the former in 1863 and the latter between 1865 and 1870, practically give a systematic account, together with excellent figures, of the whole fern flora of India. Of these excellent books a condensation in a popular and abridged form has also been issued. The fourth forest officer who has published contributions to systematic botany is Mr. W. A. Talbot, whose "List of the Trees, Shrubs and Woody Climbers of the Bombay Presidency" gives evidence of much careful research. And the fifth is Mr. J. S. Gamble, who, besides amassing at his own expense probably the largest private collection of plants ever owned in India, has published a systematic account of the Indian *Bambuseae*, a tribe of grasses which, from the peculiarity of many of the species in the matter of flowering, had so long been the bane of the Indian agrostologist. Mr. Gamble, in his monograph, gives a description and a life-sized figure of every one of the Indian species. Of this monograph (which forms a volume of the "Annals of the Botanic Garden, Calcutta") Sir Joseph Hooker writes (at p. 375. vol. vii. of his "Flora of British India"): "It is indispensable to the student of the tribe by reason of its descriptions and admirable plates and analyses." Mr. Gamble has also published a Manual of Indian Timbers. A forest officer who was ever ready to help in botanical work, but who never himself published, was Mr. Gustav Mann, for many years Conservator of Forests in Assam, but now lost to India by his premature retirement. Other forest officers, who have done, and are still doing, good botanical work in their various spheres, are Messrs. Lace, Heinig, Haines, McDonell, Ellis, Oliver, and Upendra Nath Kanjilal. Mr. Bourdillon, conservator of forests in the Travancore State, is also an enthusiastic botanist and collector.

In the Madras Presidency botanical work has been carried on during this second half of the century by Noton, Perrottet, Metz, Hohenacher, Schmidt (on the Nilgiris), Bidie and Lawson. By the efforts of the latter two, a second public herbarium was established in Madras (the first having been broken up many years ago), and in this second Madras herbarium are to be found many of the collections of Wight, besides those of the other Madras botanists just named.

In the Bombay Presidency, the only public herbarium is at Poona. This is of recent origin, and owes its existence to the devotion of four men, viz. Dr. Theodore Cooke (late principal of the College of Science at Poona), Mr. Marshall Woodrow (until recently superintendent of the garden at Guneshkind and lecturer in botany in the Poona College), the late Mr. Ranade (a native gentleman), and Dr. Lisboa (a medical practitioner in the Deccan)—all four enthusiastic botanists. The amount of Government support given to the herbarium at Poona has hitherto been very inadequate. It is to be hoped that greater liberality may be extended to it now that a stranger to the Bombay Presidency has just been appointed to its charge in the person of Mr. George Gammie, hitherto employed in the cinchona department of Bengal.

Reference has already been made to the botanic gardens at Seharunpore and Calcutta. But to complete this sketch, and especially in order to give a clear idea of the apparatus at present existing in India for carrying on the study and practice of systematic botany, it is necessary again to refer to them. On the retirement of Dr. Jameson in 1872, Mr. J. F. Duthie was selected by the Secretary of State for India as superintendent of the Seharunpore garden. Mr. Duthie is still at Seharunpore. During his tenure of office he has added to the herbarium previously existing there (which consisted chiefly of the collections of Royle, Falconer and Jameson) a magnificent collection of his own. Mr. Duthie has published a valuable book on the "Field and Garden Crops of the North-western Provinces," and another on the grasses of the same area. He is now engaged on the preparation of local floras of the North-west Provinces and of the Punjab.

The Calcutta Garden at the date of Sir J. D. Hooker's arrival in India in 1848 was under the charge of Dr. Falconer, who, in 1855, was succeeded by Dr. J. Thomson, and he in turn by Dr. T. Anderson in 1861. Mr. C. B. Clarke acted as superintendent during the interregnum between Dr. Anderson's lamented death in 1870 and my own appointment in 1871. The garden and herbarium at Calcutta have been most liberally supported by the Government of Bengal. By funds thus supplied the garden has been remodelled and improved; the herbarium has been housed in an excellent fire-proof building (erected in 1883), and the collections of which it consists have been greatly increased. The chief items of these later acquisitions have been the large contributions of Mr. C. B. Clarke; of Dr. D. Prain, for many years curator of the herbarium, and now superintendent of the garden and of the cinchona plantation and factory; of Mr. G. A. Gammie, formerly one of the staff of the cinchona plantation, and now lecturer on botany in the College of Science at Poona; of Mr. R. Pantling, deputy-superintendent of the cinchona plantation, who, in addition to dried specimens of the orchids of Sikkim, contributed nearly five hundred drawings, most of which have been lithographed as the illustrations to a book published in the "Annals" of the garden, as the "Orchid Flora of Sikkim"; of Mr. Kunstler, a collector in the Malay Peninsula; and last, but by no means least, of a trained band of aborigines of Sikkim named Lepchas who possess keener powers of observation of natural objects, more patience, sweeter tempers, and, I am bound in fairness to add, dirtier clothes than any race I have ever met—black, yellow, or white! In addition to their liberal grants to the garden and herbarium, the Bengal Government, twelve years ago, sanctioned the publication, at their expense, as occasion might offer, of monographs of important families or genera of Indian plants. These monographs are printed in quarto, and they are, with one exception, profusely illustrated by plates drawn and lithographed by Bengali draughtsmen. The series is known as "The Annals of the Royal Botanic Garden, Calcutta," and it has now reached its eighth volume, the ninth being in active preparation. These "Annals" have been contributed to by Dr. Prain (my successor at the Calcutta Garden), by Dr. D. Douglas Cunningham, Mr. J. S. Gamble, Mr. R. Pantling, and myself.

About ten years ago, it occurred to the Supreme Government of India that it might be to the interest of science if the four botanical establishments at Calcutta, Seharunpore, Madras, and Poona were to be formed into a kind of hierarchy under the designation of the Botanical Survey of India, without removing either the officers or the four institutions to which they were attached from the financial or general control of the local administrations within which they are respectively situated, the Supreme Government making a small contribution of money for the purpose of exploring little-known districts and making itself responsible for the cost of a publication called "The Records of the Botanical Survey." The four institutions just mentioned continue, therefore, to be paid for and controlled by the Governments of Bengal, the North-west Provinces, Madras and Bombay, but their superintendents are placed on the cadre of the Botanical Survey. The published Records of this Survey now extend to twelve numbers, each of which is devoted to an account of the botany of some part of the enormous and continually expanding area to be explored.

Such, then, is the machinery by which systematic, as distinguished from economic and physiological, botany is carried on within the Indian Empire. But the work done in India itself by no means represents all the work that is being carried on in connection with the elucidation of the flora of the Empire of India. On the contrary, the bulk of the work of elaborating the materials sent from India in the shape of dried specimens has always been, and must always be, done in a large herbarium; and until lately no herbarium in Asia has been sufficiently extensive. The last word on every difficult taxonomic question must still lie in Europe. A very large number of the herbarium specimens collected in India have found their way to the various centres of botanical activity in Europe, and have been described by botanists of many nationalities. The lion's share of these specimens has naturally come to the two great national herbaria in the British Museum and at Kew, but especially to the latter. It was in the Kew Herbarium that Sir Joseph Hooker and his collaborateurs prepared the flora of

British India. And it is in the Kew Herbarium that are to be found the types of an overwhelming proportion of the new species described for the first time in that monumental work. The Kew Herbarium is therefore to the Indian botanist the most important that exists. I must apologise for diverging for a moment to remind you what a type specimen is. It is the very one on which an author has founded any species to which he has given a name. And in order to determine absolutely what is the specific form to which the author meant his name to apply, it is often necessary to examine his type. This necessity increases in urgency with the extension of our knowledge of the flora of the world.

The preservation in good condition of a type specimen is therefore, from the point of view of a systematic botanist, as important as is the preservation to the British merchant to the standard pound weight and the standard yard measure on which the operations of British commerce depend. "Types" also stand to the systematic botanist much in the same relation as the national records do to the national historian. The latter are guarded in the Record Office, I understand, with all the skill which the makers of fire-proof, damp-proof and burglar-proof depositories can suggest. If, however, the type of a species happens to be deposited at Kew, what are the probabilities of its preservation? Such a type at Kew is incorporated in what is admittted to be in every sense the largest and, for its size, the most accurately named, the most easily consulted, and therefore the most valuable herbarium in the world, the destruction of which would be a calamity commensurate in extent with that of the burning of the library at Alexandria. One might therefore reasonably expect that a people who rather resent being called a "nation of shopkeepers" would feel pride in providing for this priceless national collection a home which, although perhaps somewhat inferior to that provided for the national historical records, might at least be safe from fire. This expectation is not fulfilled. The infinitely valuable Kew Herbarium and library have no safer home than an old dwelling-house on Kew Green, to which a cheap additional wing has been built. The floor, galleries and open inner roof of this additional wing are constructed of pine coated with an inflammable varnish, and on the floor and galleries are arranged cabinets (also made of pine-wood) in which the specimens (which are mounted on paper) are lodged. The provision of a fireproof building, capable of expansion as the collections extend, is surely not beyond the means of an exchequer which last year netted over one hundred and six millions sterling of revenue. On behalf of the flora of India, I venture to express the hope that the provision of a proper home for its types may receive early and favourable consideration by the holders of the national purse-strings. But India is by no means the only portion of the Empire interested in this matter, for the types of the Australasian floras, those of a large part of the North American flora, and those of many species inhabiting countries outside British rule or influence, find their resting-place at Kew. The safe custody of the Kew Herbarium is, therefore, not merely a national, but a cosmopolitan responsibility.

In this Address I have hitherto made little reference to cryptogamic and economic botany. As regards cryptogamic botany there is little to relate. Except Griffith, no Indian botanist of the earlier of the two periods into which I have divided my sketch ever did any serious work amongst non-vascular cryptogams. During the second period two men have done gallant work under difficulties which no one who has not lived in a tropical country can thoroughly appreciate. I refer to Drs. Arthur Barclay and D. D. Cunningham. The former made some progress in the study of uredinous fungi, which was cut short by his untimely death; while the latter, in addition to his bacterial and other researches connected with the causation of human disease, conducted protracted investigations into some diseases of plants of fungal or algal origin. Some of the results of Dr. Cunningham's labours were published in the *Transactions* of the Linnean Society, and in a series entitled the "Scientific Memoirs, by Medical Officers of the Indian Army." To the "Annals of the Botanic Garden, Calcutta," Dr. Cunningham also contributed elaborate memoirs on the phenomena of nyctitropism, and on the mode of fertilisation in an Indian species of Ficus (*F. Roxburghii*). There is no doubt that, in the past, cryptogamic botany has not been studied in India as it ought to have been and might have been. This discredit will, I hope, be soon removed; and I trust that, by the time the twentieth century opens, a cryptogamist may have been appointed to the staff of the Calcutta Botanic Garden. The collecting of cryptogams was not, however, altogether neglected in India in times past. For, from materials sent to England, Mitten was able to elaborate a moss flora of India, while Berkeley and Browne were enabled to prepare their account of the fungi of Ceylon. George Wallich, in whom the botanical genius of his father burnt with a clear though flickering flame, did some excellent work amongst Desmids, and was among the earliest of deep-sea dredgers.

Economic botany has, on the other hand, by no means been neglected. It was chiefly on economic grounds that the establishment of a botanic garden at Calcutta was pressed upon the Court of Directors of the East India Company. And almost every one of the workers whose labours I have alluded to has incidentally devoted some attention to the economic aspect of botany. Roxburgh's "Flora Indica" contains all that was known up to his day of the uses of the plants described in it. Much of Wight's time was spent in improving the races of cotton grown in India. The botanists of the Seharunpore garden during the middle of the century were especially prominent in this branch of botanical activity. Royle wrote largely on cotton and on other fibres, on drugs, and on various vegetable products used, or likely to be of use, in the arts. These botanists introduced into the Himalayas more than fifty years ago the best European fruits. From gardens which owe their origin to Royle, Falconer and Jameson, excellent apples grown in Gharwal and Kamaon are to-day purchasable in Calcutta. Peaches, nectarines, grapes, strawberries, of European origin, are plentiful and cheap all over the North-west Himalaya, and are obtainable also in the submontane districts. Potatoes, and all the best European vegetables, were introduced long ago; and at Seharunpore there is still kept up a large vegetable garden from which seeds of most European vegetables are issued for cultivation during the cold season in the gardens of the various regiments of the Queen's troops quartered in Upper India. More or less attention has been given in the past by Government botanists in India generally to the improvement of the cultivation of flax, hemp, rheea, tobacco, henbane, dandelion, vanilla, sarsaparilla, coffee (Arabian and Liberian), cocoa, ipecacuanha, aloes, jalap, india-rubber, Japanese paper-mulberry, cardamoms, tapioca, coca, tea and cinchona. Only to three economic enterprises, however, have I time to allude in any detail. These are (1) the cultivation of tea, (2) the introduction of cinchona, and (3) the formation of the Forest Department. But before proceeding to the consideration of these I wish to give a short account of the inauguration of the office of Reporter on Economic Products. Up to the year 1883 there had been no special Government department in India for dealing with questions connected with the natural products of the Empire. Whatever had been done prior to that date (and the amount was by no means unimportant) had been the result of isolated and uncoordinated effort. In 1883 the Government of India founded a department for dealing with the economic products of the Indian Empire, and under the title of Reporter on these products they were fortunate enough to secure Dr. George Watt, a member of the Bengal Educational Service. Dr. Watt is an accomplished and able botanist. He has collected Indian plants largely, and has made numerous notes both in the field and in the bazaar. The great work which, on the initiative of Sir Edward Buck, Secretary to the Department of Revenue and Agriculture, and of Sir W. Thiselton-Dyer, of Kew, Dr. Watt began and carried to a successful termination was the compilation of his "Dictionary of Economic Products," in which valuable book is collected all that is known of almost every Indian product, whether vegetable, animal or mineral. The study of economic botany is now pursued in India as part of a highly specialised system of inquiry and experiment. Dr. Watt has a competent staff under him in Calcutta, one of whom is Mr. D. Hooper, well known for his original researches into the properties of various Indian drugs. Dr. Watt has arranged in Calcutta a magnificent museum of economic products, and there is no doubt the economic resources of the Empire are now being studied with as much energy as intelligence.

Tea cultivation is one of the enterprises in the introduction and development of which botanists took a very leading part. The advisability of introducing the industry was first pressed on the attention of the East India Company by Dr. Govan (of Seharunpore), and in this he was seconded by Sir Joseph Banks as President of the Royal Society. Royle in 1827, and Falconer

slightly later, again urged it as regards the North-west Himalaya. In 1826 David Scott demonstrated to rather unwilling eyes in Calcutta the fact that real tea grows wild in Assam. In 1835 Wallich, Griffith and McClelland were deputed by Government to visit Assam, to report on the indigenous tea. In the year 1838 the first consignment of Indian-grown tea was offered for sale in London. The consignment consisted of twelve chests containing 20 lbs. each. This first sample of 240 lbs. was favourably reported upon. Last year the exports of tea from India to all countries reached 157 millions of pounds, besides 120 millions of pounds exported from Ceylon!

The introduction of cinchona into India originated purely with the Government botanists. As everybody knows, quinine, and to a less extent the other alkaloids present in cinchona bark, are practically the only remedies for the commonest, and in some of its forms one of the most fatal, of all Indian diseases, viz. *malarious fever*. The sources of supply of the cinchona barks in their native countries in South America were known to be gradually failing, and the price of quinine had for long been increasing. The advisability of growing cinchona in the mountains of British India was therefore pressed upon Government by Dr. Royle in 1835, and he repeated his suggestions in 1847, 1853 and 1856. Dr. Falconer, in his capacity of superintendent of the Botanic Garden, Calcutta, made a similar suggestion in 1852; and his successors at Calcutta, Dr. T. Thomson and Dr. T. Anderson, in turn advocated the proposal. In 1858 Government at last took action, and, as the result of the labours of Sir Clements Markham and Sir W. J. Hooker, of Kew, the medicinal cinchonas were finally, in the period between 1861 and 1865, successfully introduced into British India—on the Nilgiris under Mr. McIvor, and on the Sikkim-Himalaya under Dr. T. Anderson. Various experiments on the best mode of utilising the alkaloids contained in red cinchona bark resulted in the production in 1870 by Mr. Broughton, quinologist on the Nilgiri plantation, of an amorphous preparation containing all the alkaloids of that bark. This preparation was named *Amorphous Quinine*. Somewhat later (1875) a similar preparation, under the name of *Cinchona Febrifuge*, was produced at the Sikkim plantation by Mr. C. H. Wood, the quinologist there; and of these drugs about fifty-one tons have been distributed from the Sikkim plantation up to the end of last year. The preparation of pure quinine from the yellow cinchona barks, so successfully grown in the Sikkim plantation, long remained a serious problem. The manufacture of quinine had hitherto been practically a trade secret. And when the Indian Government had succeeded in providing the raw material from which a cheap quinine might be made for distribution amongst its fever-stricken subjects, the knowledge of the means of extracting this quinine was wanting. Philanthropic platitudes were freely bandied about as to the immensity of the boon which cheap quinine would be to a fever-stricken population numbering so many millions. But there was a singular absence of any practical help in the shape of proposals, or even hints, as to how quinine was to be extracted from the rapidly increasing stock of crown and yellow bark. The officers in charge of the cinchona plantations in India had therefore to do their best to solve the problem for themselves. And it was ultimately solved by Mr. C. H. Wood, at one time Government quinologist in Sikkim, who suggested, and Mr. J. A. Gammie, deputy-superintendent of the plantation there, who carried into practice, a method of extraction by the use, as solvents of the cinchona alkaloids, of a mixture of fusel-oil and petroleum. The details of this process were published in the *Calcutta Official Gazette*, for the benefit of all whom it might concern. Very soon after the introduction of this method of manufacture, the Government factories in Sikkim and the Nilgiris were able to supply the whole of the Government hospitals and dispensaries in India with all the quinine required in them (some 5000 or 6000 pounds annually), besides providing an almost equal quantity for the supply of Government officers for charitable purposes. The latest development of the quinine enterprise in India has been the organisation of a scheme for the sale at all the post-offices in the province of Bengal, and in some of those of Madras, of packets each containing five grains of pure quinine, that being a sufficient dose for an ordinary case of fever in a native of India. These packets (of which some are on the table for distribution) are sold at one pice each, the pice being a coin which is equal, at the current rate of exchange, to one farthing sterling!

In conclusion, I wish to make a few remarks on the third great economic enterprise connected with botany in India, viz. the Forest Department. The necessity for taking some steps to preserve a continuity of supply of timber, bamboos and other products from the jungles which had for generations been exploited in the most reckless fashion, was first recognised by the Government of Bombay, who in 1807 appointed commissioners to fix the boundaries of and to guard the forests in that Presidency. This scheme was abandoned in 1822, but was resumed in a modified form during 1839–40. Seven years later a regular forest service was established in Bombay, and Dr. Gibson was its first head. Dr. Gibson in turn was succeeded by Mr. Dalzell—and both were botanists. In the Madras Presidency the first man to recognise the necessity of perpetuating the supply of teak for ship-building was Mr. Connolly, collector of Malabar, who in 1843 established a teak plantation at Nelumbur, which has been carried on, and annually added to, down to the present time. In 1847 Dr. Cleghorn (a botanist) was appointed to report on the conservation of the forests of Mysore (which contained the well-known sandal-wood), and the following year Lieutenant Michael (still with us as General Michael, a hale and hearty veteran) was appointed to organise and conserve the public forests in Coimbatore and Cochin. The crowning merit of General Michael's administration was the establishment, for the first time in India, of a system of protection against the fires which annually used to work such deadly havoc. In 1850 the British Association, at their Edinburgh meeting, appointed a committee to consider and report upon the probable effects, from an economic and physical point of view, of the destruction of tropical forests. This committee's report was submitted to the Association at the meeting at Ipswich in 1851. The weighty evidence collected in this report so impressed the Court of Directors of the East Indian Company that, within a few years, regular forest establishments were sanctioned for Madras and British Burma, the two main sources of the supply of teak.

In 1856 Mr. (now Sir Dietrich) Brandis was appointed to the care of the forests of the latter province. These forests had been the object of spasmodic efforts in conservancy for many years previously. In 1827 Dr. Wallich reported on the teak forests, and five years later a small conservancy establishment was organised, officered by natives. This, however, was kept up for only three or four years. In 1837 and 1838 Dr. Helfer reported on these forests, and an English conservator was appointed. In 1842 and 1847 codes of forest laws were drawn up, but do not appear to have been enforced to any extent. In 1853 Dr. McClelland was appointed superintendent, but he continued to hold the office for only a short time. A few years after Sir Dietrich Brandis's assumption of the charge of the Burmese forests, he was appointed Inspector-General of all the Government forests in British India; and it is to him that we owe for the most part the organisation of the Indian Forest Department as it now exists. That organisation includes two schools of forestry (in both of which botany is taught), one in connection with Coopers Hill and the other at Dehra Dun in Upper India. The latter has for many years been under the direction of a gentleman who is distinguished both as a forester and as a botanist. In the Coopers Hill School the higher grades of forest officers receive their training; at Dehra Dun those of the lower grades receive theirs. The officers of the department on the Imperial list, according to the latest official returns, now number 208, divided into the grades of conservator, deputy- and assistant-conservator, with a single inspector-general as chief. In addition to these, there are 566 provincial officers, ranking from rangers upwards to extra deputy-conservators.

Botanists took a leading part in moulding the department in its earlier years; for, as already stated, its pioneers—Gibson, Dalzell, Cleghorn, Anderson, Stewart and Brandis—were all botanists. And to most people, who give even casual attention to the matter, it appears fitting that the possession of a knowledge and liking for botany should form a strong characteristic of officers whose main duties are to be in the forest. And this belief did for some time exercise considerable influence in the selection of recruits for the department. But, except in the Dehra Dun School, it does not appear to guide the department any longer. For example, at the entrance examination to the Forest School at Coopers Hill, only three subjects are obligatory for a candidate, viz. mathematics, to which 3000 marks are allowed; German, to which 2000 are allowed; and English, for which 1000 are given. Botany is one of the nine optional

subjects, of which a candidate may take up two, and in each of which 2000 marks may be made.

Botany is taught at Coopers Hill, and (according to the Calendar of the College) it forms one of the "special auxiliary subjects" for the forest student. I do not wish to say a single word in depreciation of the botanical teaching at this college, which is probably excellent of its sort. I do not know what value, as part of their professional equipment, students are accustomed or encouraged to attach to the possession of the means of acquiring a knowledge of the trees and shrubs in the midst of which they are to pass their lives in India. But this I do know, that the ordinary forest officer educated in England now arrives in India without sufficient knowledge to enable him to recognise from their botanical characters the most well-marked Indian trees. To tell such an officer the name of the natural family to which a plant belongs conveys no information to him whatever, for he knows nothing of botanical affinities. Moreover, the forest officer after he has arrived in India is not encouraged to familiarise himself with the contents of the forests under his charge. This will be better appreciated by giving an example than by any number of remarks. Some three years ago, Mr. J. S. Gamble (a forest officer) published a monograph of the bamboos of British India. From bamboos, as you may possibly be aware, a very large amount of forest revenue is annually derived. The sales of bamboos for the year 1896 97 amounted to no less than 110 millions of stems. A great number of the species of bamboos have the curious habit of flowering gregariously at remote intervals of thirty or forty years, and the flowering is followed by death. The absence from the forests for years in succession of flowers of a number of the species, and the similarity of many of them in leaves, had hitherto made members of the group most difficult of identification. Mr. Gamble had devoted himself to their study for many years. He had carefully examined all the previously collected materials stored in the herbaria at Kew, the British Museum, Calcutta and elsewhere; and large special collections had been made for him by Mr. Gustav Mann and other officers of the Government. Moreover, he had General Munro's great paper in the Linnean *Transactions* as a basis. Mr. Gamble's work was undertaken with the full approval of Sir Joseph Hooker, who indeed accepted Mr. Gamble's account of the bamboos for his "Flora of British India." Mr. Gamble's monograph is illustrated by a life-sized drawing of each species, with analyses of the flowers on a larger scale. When completed, the book was published as one of the volumes of the "Annals of the Calcutta Botanic Garden." In consideration of the supposed great importance of the book to the forester, and in the belief that the copies would be eagerly taken by the Forest Department, an extra hundred copies were printed, and these hundred copies were put into stout canvas binding suitable for camp use. These copies, or as many of them as he cared to take, were offered to the head of the Forest Department in India at the reduced price of fifteen rupees per copy. The result was an official refusal to buy a single one, although the purchase of the whole hundred (which was not asked for) would have cost only fifteen hundred rupees—a sum which would have reduced the revenue of the year by about one twelve-thousandth part! An appeal against this ruling having been made to a still higher authority, a modified order was subsequently issued permitting such forest officers as desired to possess the book to buy copies and charge the cost in their office expenditure. I may state that the book was not a private venture. It was produced at the expense of the Government of Bengal.

It is not because I like to play the censor that I have made these remarks about the Forest Department. Having myself served in it from 1869 to 1871, I can speak from my own experience as to the value, from the utilitarian point of view, of a knowledge of the names, affinities and properties of the trees, shrubs and herbs which compose an Indian jungle, and of a knowledge of these as individual members of the vegetable kingdom rather than as masses of tissue to be studied through a microscope. The appointment which I held in India for twenty-six years after leaving the Forest Department gave me full opportunity of getting into touch with all who interest themselves in a knowledge of plants, and of discovering how few of these at the present day are forest officers. The majority of the latter, if they love their trees, are content to do so without knowing their names or relationships! There are, of course, splendid exceptions who know as well as love. The general decadence of the teaching of systematic botany in England during the past twenty years is, perhaps, to some extent the cause of the low estimation in which the science is held by the authorities of the Indian Forest Department. Twenty-five years ago systematic and morphological botany, no doubt, had too great prominence given to them in the teaching at universities and colleges of this country, and the other branches of botanical science were too much neglected, although I do not think they were despised. Now it appears to me that systematic botany is too much neglected. I hope it is not also despised! Few of the systematists who survive in England are now to be found attached to the universities. They are mostly clustered round the two great herbaria in London; and such of them as have to look to systematic botany for the means of livelihood are not in the receipt of salaries such as one might reasonably expect in one of the richest countries in the world!

## *CHEMISTRY AT THE BRITISH ASSOCIATION.*

DESPITE the fact that the Dover meeting was a comparatively small one, the chemists formed a thoroughly representative gathering, including amongst distinguished foreigners Prof. Lemoine, of Paris; Prof. Fittig, of Strassburg; and Prof. Ladenburg, of Breslau. The able address of the President, Dr. Horace T. Brown, on the assimilation of carbon by the higher plants, which embodied most valuable and original contributions to the knowledge of the complex changes which go on in the living cell, introduced a subject somewhat beyond the usual scope of the proceedings of the Section; and whilst the chemists present at Dover will always look back upon the address with a special appreciation, they will be equally mindful of the many interesting contributions on kindred subjects for which the personality of the President was in the main responsible. Prof. Hanriot, the President of the Chemical Section of the French Association, communicated a short account of the excretory products of plants, in which he discussed the mutations of nitrogen in the vegetable kingdom as based on his own observation of the occurrence of asparagine amongst the secretions of plant roots; when passed into the soil this product would in all probability become oxidised to nitrates, and thus become directly available for plant life. The experimental confirmation of this view is in course of study. The chemical processes involved in the saccharification of starch by malt-diastase were discussed by Dr. A. Fernbach, of the Institut Pasteur, and by Dr. G. H. Morris. The former detailed his observations on the influence of acids and of some salts on saccharification, which led him to the conclusion that the slightest trace of any free acid retards the action of diastase on gelatinised as well as on soluble starch, provided both the starch and diastase are free from salts on which the added acid may act; but if the solution contains salts, such as secondary phosphates, which are distinctly unfavourable to diastatic action, the addition of acid is favourable as long as there is no excess over the quantity necessary to transform these salts into the primary phosphates. The President regarded these results as opposed to his own observations on the subject, and considered further details of the experiments necessary to justify the conclusions. Dr. G. H. Morris, in a paper on the combined action of diastase and yeast on starch granules, showed that similarly to the symbiotic action of diastase and yeast on the so-called stable dextrin, ungelatinised intact starch granules, when submitted to the joint action of diastase and yeast, are fermented to a large extent, the maltose first formed being converted into alcohol. The addition of a small quantity of yeast to a cold water malt extract more than doubles the percentage of starch that is changed, and this increased action is not due to any greater activity of the diastase that might result from the removal of the soluble product formed (maltose) from the sphere of action. It appears necessary to have both the diastase and the yeast present together in a condition capable of exercising their respective functions for the increased action to occur. The action of acids on starch was also discussed by Dr. Morris, who showed that maltose is always obtained as a product of hydrolysis together with dextrin and dextrose; this is in opposition of H. Johnson's statement that the two latter compounds are the sole products of the action. But the most interesting contribution to this branch of chemistry was the joint discussion with Section K (botany) on symbiotic fermentation, on the occasion of the visit of the French Association. The discussion

was opened by Prof. Marshall Ward, who was followed by Sir Henry Roscoe, Prof. Armstrong, M. van Laar, Prof. Reynolds Green, Prof. Warington, M. Tanret, Prof. Francis Darwin and Dr. G. H. Morris. There is little doubt that the discussion has led to a more exact recognition of the division and relations of symbiotic changes, which should serve to develop the study of the subject. Prof. Marshall Ward, after considering the conditions under which symbiosis exists both in the vegetable and animal kingdoms, passed to the more special subject of symbiotic fermentations. Prof. Ward instanced the various grades of symbiotic association that may be recognised, suggesting a special nomenclature, and concluded his remarks with the consideration of the physiology of the subject. The many possibilities that may arise in the mutual life of symbiotic organisms—such as the provision of definite food material by one symbiont for the other, or the advantage derived from a protective influence, or, finally, the exertion of a stimulating action—were discussed, with the conclusion that there is some evidence to support the hypothesis that one symbiont may stimulate another by excreting a body which acts as an exciting drug to the associated organism. The chemical aspect of the subject was concisely treated by Prof. Armstrong, who pointed out that there is an absence of positive evidence to show that one member of a pair of symbiotic organisms does more than prepare the way for the other by effecting a change which the second is incapable of inducing. The possibility of chemical interaction playing a part in symbiotic changes and the hydrolytic function of enzymes were clearly brought out, and illustrations of allied changes of a purely chemical character instanced. Prof. Armstrong pointed out that no case has yet been observed in which a substance is attacked by a pair of organisms neither of which can attack it singly, and regarded it as probable that associated molecules undergo change under the influence of a single organism or agent which determines their association. Prof. van Laar, on the other hand, expressed the view that symbiosis was rather a case of parasitism. Dr. Calmette's contribution on industrial symbiotic fermentations was read, in his unavoidable absence, by Sir Henry Roscoe. In this paper an account was given of the methods for the conversion of starch into alcohol by the association of pure cultures of moulds with pure yeast cultures, and the industrial application of this symbiotic relation. Both in France and in Belgium thousands of tons of starch are now converted into alcohol by this method, and most favourable results have been obtained both as regards yield and quality. In inorganic chemistry Prof. Dewar's important experiments on the solidification of hydrogen stands foremost; an account of these researches has already appeared in NATURE. Colonel Waterhouse contributed a note on a remarkable result he has observed on the exposure of metallic silver to light; a visible image results on the exposed plate after prolonged exposure, but the effect may be recognised in a very much shorter space of time by the development of the latent image produced. An important discussion on the proposal of establishing an International Committee on Atomic Weights was initiated by Prof. F. W. Clarke in the form of a letter to Prof. Tilden, who himself contributed a critical *résumé* of both the theoretical and practical aspects of the question. In view of the proposed discussion of the subject at the Congress of Chemists to be held in Paris next year, Prof. Clarke's proposal for an International Committee aroused much interest; but the exact scope of its work appeared difficult to define in the minds of Sir Henry Roscoe, Prof. Fittig, Sir William Crookes and others who participated in the discussion. The desirability of encouraging all capable of undertaking the redetermination of atomic weights was fully recognised, but such work could not be ordered. This view, of course, referred to the theoretical part of the problem; Prof. Tilden's suggestion regarding the desirability of an understanding as to the numbers to be chosen for ordinary use was somewhat lost sight of by many of the speakers, especially his important addendum that the values arrived at in atomic weight determinations are obtained under conditions which cannot be observed in daily laboratory practice, and that the adoption, therefore, of numbers regarded as the most exact does not of necessity contribute to the exactness of ordinary analytical observations. Dr. Gladstone's report on the teaching of natural science in elementary schools was followed by an interesting discussion; Dr. Gladstone, in conjunction with Mr. Hibbert, also contributed a paper dealing with some peculiarities in the drying of colloids such as the hydrates of silica, tin, titanium, iron and alumina.

The papers, reports, and discussions dealing with organic chemistry were of more than usual importance. Prof. Hartley read the first report of his committee on the absorption spectra and chemical constitution of organic substances, which, in addition to the work of the committee, contains a valuable summary of that of other investigators. The committee on the action of light upon dyed colours issued their final report, which completes a long series of important experiments carried out chiefly by Prof. Hummel. Prof. Armstrong opened a discussion on laws of substitution, especially in benzenoid compounds, in which the conditions of substitution in amines and phenols were dealt with. The course of the reaction in those cases in which ortho- and para-compounds, on the one hand, and essentially meta-compounds, on the other, result were discussed, and the possibility of the formation of intermediate products in the former case which subsequently undergo isomeric change fully considered. Prof. Armstrong also contributed papers on the relative orienting power of chlorine and bromine, and on isomorphism in benzene sulphonic derivatives. Extremely interesting isomorphous relations have been observed amongst these latter compounds, and a committee was appointed by the Section for their further investigation. Mr. Fenton read a summary of his researches on oxidation in presence of iron, in which the extension of his reaction to tartronic, lactic, glyceric and malic acids was referred to, and, in conjunction with Mr. Jackson, described the condensation products obtained from glycollic aldehyde under the influence of dilute alkali. $\beta$-Acrose appears to be formed when a 1 per cent. solution of caustic soda is used, whilst a starch-like product results when the aldehyde is heated to $160^{\circ}$–$170^{\circ}$. Messrs. Morrell and Crofts gave an account of further experiments on the action of hydrogen peroxide on carbohydrates in presence of iron salts, the most interesting result obtained being the formation of a dibasic six-carbon atom acid from glucosone. Special interest centred in a paper by Mr. W. J. Pope on the influence of solvents on the optical activity of organic compounds, in which he traced the variations in the specific rotation of an optically active substance dissolved in various solvents to the degree of association of the active compound, and on this association factor founded a method for determining whether a particular optically active substance forms a liquid racemic compound with its optical antipode. Mr. Pope also described a new method for resolving racemic oximes into their optically active components, and Dr. M. O. Forster gave an interesting account of his researches on the influence of substitution on optical activity in the bornylamine series. Dr. Forster also described some new derivatives of camphoroxime, the chief interest of which lies in their relation to certain oxidation products of camphor. Dr. C. A. Kohn and Dr. W. Trantom, in a paper on the action of caustic soda on benzaldehyde, showed that, in the absence of water or in the presence of an excess of aldehyde, benzyl-benzoate is formed as a product of the decomposition; its production points to the formation of an intermediate ortho-compound in the reaction commonly employed in the preparation of benzyl alcohol. Prof. Emerson Reynolds described some new silicon compounds obtained by the action of ethyl mustard oil on silico-phenyl-di-imide, and Prof. Ladenburg read a summary entitled "The development of chemistry in the last fifteen years," in which the advances of the various branches of the science during that period were dealt with. Of more general interest was a paper by Prof. Clowes on intermittent bacterial treatment of raw sewage in coke beds, which was followed by one by Mr. W. Scott-Moncrieff on the place of nitrates in the biolysis of sewage. Both papers, as well as the report of the committee on water and sewage examination results, led to an interesting and useful discussion. In a paper on the chemical effect on agricultural soils of the salt-water flood of November 29, 1897, on the East Coast, by Messrs. T. S. Dymond and F. Hughes, the remarkable result was recorded that although the proportion of salt left on the soil was insufficient to prove injurious to the growing crops, the earth-worms in the soil were entirely removed, with the consequence that very few crops were worth harvesting the following year. This year nine-tenths of the salt originally present has disappeared from the soil, and young worms have again made their appearance, but still the condition of the soil remains unsatisfactory, the rate of percolation of water through the flooded soil being only half as rapid as through the unflooded. This the authors trace to the action of the chlorides of the sea water on the double silicates of the soil with the formation of silicate of alumina in a gelatinous condition,

## GEOLOGY AT THE BRITISH ASSOCIATION.

ABANDONING on this occasion the customary procedure of opening the proceedings with the presidential address, Section C plunged at the first meeting into the midst of its work with a long list of papers. The reason for this change was that Sir Archibald Geikie's address might be heard on Saturday by the visiting members of the French Association between their reception in the Town Hall and their entertainment at luncheon in the College Close. The arrangement proved highly successful, and the President's eloquent demand that geologists should be allowed to investigate the duration of geological time for themselves with data at their command, unhampered by the vague speculations in which the physicists have indulged, was listened to by a crowded audience, the platform being occupied by a distinguished group of British and foreign men of science.

As befitted their importance and local interest, the first papers taken on Thursday were those relating to Coal-exploration in Kent. Mr. R. Etheridge dealt at some length with the relations between the Dover and Franco-Belgian Coal-basins, without, however, adding much new information to what is already known. Prof. W. Boyd Dawkins, after once more reviewing the history of the discovery, gave some valuable data respecting the boring carried on under his supervision at Ropersole, eight miles north-west of Dover, where Coal-measures have been struck at a depth of 1580 feet, after Chalk, Gault, Lower Greensand, Wealden, Corallian, Oxfordian, Bathonian and Liassic strata had been passed through, and respecting other borings at Ottinge, Hothfield, Old Soar near Tonbridge and Penshurst, of which the first, at a depth of 730 feet, is in Kimeridge Clay; the second, at 800 feet, in Portlandian beds; the third, at over 700 feet, in Hastings Sands; and the last, at 1867 feet, in Kimeridge Clay. From these data, Prof. Dawkins concludes that the southern boundary of the concealed coal-basin ranges under the southern scarp of the North Downs for some distance to the westward of Dover, along the line marked by the Pembroke-Mendip anticline, and that to the south of this anticline the Palæozoic floor is probably composed of pre-Coal-Measure rocks.

The discussion elicited by these two papers was scarcely worthy of the subject, perhaps from the matter having lost its freshness through so much having been written upon it.

At the same meeting Mr. W. Gibson, of H.M. Geological Survey, contributed a short account of the results of his investigations among the Upper Carboniferous rocks of North Staffordshire, which have an important bearing upon the question of the coal-fields lying concealed beneath the Red Rocks of the Midland counties. Mr. Gibson showed that considerable areas of so-called Permian rocks in the region which he has examined are conformable to the Upper Carboniferous strata and cannot be separated from them. By working out the details of these strata he has been able to detect true Upper Coal-Measures farther westward than has hitherto been done, and has found evidence that on the north-west side of the North Staffordshire anticline the valuable coal-measures and ironstones do not uninterruptedly descend beneath the so-called Permian, but rise locally westward and are nearer the surface than might have been expected.

Another paper of stratigraphical interest was that of Mr. A. J. Jukes-Browne on a recent boring through the Chalk and Gault near Dieppe, which shows that the Folkestone and Wissant facies of the Gault extend southward as far as Dieppe, a distance of about fifty-two miles.

Owing to the lantern being available on two days only during the meeting, viz. on Friday and Monday, it became necessary to take all papers requiring this method of illustration on these days, and the usual grouping of the contributions according to subject was, in consequence, only partially possible. At Friday's session Dr. A. W. Rowe gave an account of the methods by which he has attained such magnificent results in the photomicrography of opaque objects, illustrating his address by a representative series of views to demonstrate the value of this mode of research in the study of the minute structure of fossils. Dr. G. Abbott then discussed the formation of concretions; and Dr. H. J. Johnston-Lavis dealt with that thorny question the origin of oolitic structure, renewing the debate begun last year at Bristol and strongly combating Mr. Wethered's view that the structure was originally organic. Unfortunately, Mr. Wethered was not present to sustain his case, but there was nevertheless an instructive discussion. Prof. W. J. Sollas in a short note on a cognate subject, the origin of flint, stated that he had recently found the hollow casts of sponge-spicules in abundance in the chalk in the vicinity of bands of flint both in Oxfordshire and on the Kentish coast, thus sustaining the view that the silica of the nodules was derived from this source.

Mr. E. Greenly described at this session some remarkable funnel-shaped pipes of hard sandstone in the Carboniferous Limestone of Dwlbau Point, East Anglesey, due to contemporaneous erosion of an exceptional kind; and he also gave an account of the glacial phenomena of the same locality. Prof. P. F. Kendall had an excellent paper on extra-morainic drainage in Yorkshire, in which he claimed that numerous abnormal valleys in the Eastern Moorlands and in the hills west of the Vale of York must have been excavated by the drainage of lakes formed at the margin of the ice-sheet during the glacial period; and Mr. J. Lomas put forward some new ideas respecting the formation of lateral moraines and rock-trains in glaciers.

On Saturday, as already mentioned, the president delivered his address, which constituted the only business of the Section.

On Monday a long list of papers was taken, including several with lantern illustration. Prof. Sollas discussed Homotaxy and Contemporaneity, showing that Huxley's well-known contention could not be sustained and had led to much misunderstanding of the value of fossil evidence. Prof. W. W. Watts briefly described a smoothed and grooved surface of Mount Sorrel Granite underlying undisturbed Keuper Marl, and his paper led to one of the best discussions of the meeting as to the climatal conditions of Triassic times, most of the speakers agreeing that the surface in question had probably been worn by wind-driven sand, and that it afforded further evidence of desert conditions during the period. Another short paper of high importance was that of Prof. A. Renard on the origin of Chondritic Meteorites, in which it was shown that the rock-structure of certain of these extra-terrestrial fragments presented the familiar phenomena of dynamo-metamorphism. As the president remarked in the discussion, it is not often that the geologist can apply the principles of his science beyond the sphere he inhabits.

The local effects of coast-erosion were next described and well illustrated by Captain McDakin and Mr. G. Dowker, after which Mr. W. Whitaker presented the first fruits of the efforts recently made by the Council of the Association to obtain from the coastguards all round our shores, with the sanction of the Lords of the Admiralty, schedules of information as to the changes due to the action of the sea.

Mr. Vaughan Cornish then exhibited a series of photographs of Wave-phenomena, and discussed the relations between wave-forms in different substances, a discussion which was renewed at a later session. The eruption of Vesuvius in 1898 was described and illustrated by Dr. Tempest Anderson; while Prof. G. Platania contributed an account of the recent volcanic phenomena of Mount Etna; and an excellent day's work was concluded by a report by Prof. P. F. Kendall on the results obtained by a local committee, by the use of chemical reagents, as to the flow of underground waters in the limestone district of Craven in Yorkshire at the sources of the Aire. A committee of the Association was formed to continue these researches, and a grant of 50*l*. was obtained in aid of the expenses.

The first paper taken on Tuesday was that of Prof. W. Boyd Dawkins on the geology of the Channel Tunnel, in which, after indicating the conditions under which the proposed tunnel would have been made, it was stated that in the portion 2300 yards long already excavated on the English side, the Lower Grey Chalk was soft enough to be easily cut by machine and hard enough to stand without lining, and that five years' exposure had not sensibly affected its cut surface. It was generally conceded by the speakers in the subsequent discussion that the geological conditions were peculiarly favourable for the construction of the tunnel, and that, apart from the political question, no insuperable difficulty was likely to be encountered.

Mr. F. W. Harmer then read a carefully prepared paper on a proposed new classification of the Pliocene deposits of the east of England, in which he suggested the terms *Lenhamian* for the Lenham Beds, *Gedgravian* for the Coralline Crag, *Waltonian*, *Newbournian* and *Butleyan* for different portions of the Red Crag, *Icenian* for the Norwich Crag, and *Chillesfordian* and *Weybournian* respectively for the Chillesford and Weybourne deposits. The author considers the Red Crag to have accumulated in shallow inlets which were silted up one after another during a slow upheaval of the southern part of the area. In a

second paper Mr. Harmer discussed the meteorological conditions of North-western Europe during the Pliocene and Glacial periods, finding in the early glaciation of Scandinavia, and the consequent establishment of anticyclonic conditions over that area, a probable solution of the change in the direction of the prevalent winds which he believes to be necessary to account for the accumulation of the crag-deposits on our eastern coast.

A short paper by Rev. J. M. Mello on some palæolithic implements of North Kent, and the exhibition on behalf of Mr. B. Harrison of a collection of "eoliths" from the neighbourhood of Ightham, led to a brisk discussion, in which Sir John Evans, Prof. Boyd Dawkins and other speakers denied that the so-called "eolithic implements" showed proof of human workmanship, while Prof. T. Rupert Jones stated Mr. Harrison's view of the case and was supported by Mr. Allen Brown.

The chief paper of the final session on Wednesday was that of Mrs. M. M. (Ogilvie) Gordon on sigmoidal curves in the earth's crust. This admirably rendered discourse was supplementary to the work recently published by Mrs. Gordon in the *Quarterly Journal of the Geological Society* and in NATURE, and had for its object the general statement of the phenomena which are presented when rock-folds in two directions intersect each other and produce "crust-torsion," with particular reference to the earth-forms which have been thus produced in the Alpine mountain-system. The complexity of the subject seemed to daunt most of the speakers in the discussion; but Prof. Lapworth pointed out how well the results of Mrs. Gordon's field-work agreed with the theoretical deductions to be drawn from the study of intercrossing earth-waves.

As usual, some of the most solid work of the Section was embodied in the reports of the committees of research which were presented during the meeting, but of which lack of space forbids more than the bare mention. Among these were the reports presented by Prof. A. P. Coleman on Interglacial Beds in Canada; by Mr. P. M. C. Kermode on the Deposits containing Elk remains in the Isle of Man; by Prof. P. F. Kendall on Erratic Blocks; by Rev. G. C. H. Pollen on the Ty Newydd Caves; by Mr. H. Bolton on the Uphill Caves; and by Prof. W. W. Watts on Geological Photographs.

Short afternoon excursions, which have become an established feature of the Section's arrangements, were made during the week to the Ropersole Coal Boring, to the colliery works under Shakespeare Cliff, to the East Cliff and St. Margaret Bay, and to the Warren at Folkestone.

To sum up the proceedings of the week—the sessions of the Section were well attended throughout, and the papers, though without any especially salient features, maintained a good average both in numbers and quality. Some palæontological papers which might have found place in the Section were taken in Sections D and K, and this branch of geological science was in consequence scantily represented in the list.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Mr. W. L. H. Duckworth has been appointed to the University lectureship in physical anthropology.

Mr. R. G. K. Lempfert has been appointed Assistant Demonstrator in Experimental Physics.

It is proposed that McGill University, Montreal, be adopted as an institution affiliated to the University.

A NEW technical institute is to be erected, at a cost of 8450*l.*, in Carisbrooke Road, Liverpool.

THE sum of 25,000 dollars has been promised to Vassar College towards a biological laboratory on condition that an equal amount be raised for the same purpose by other means.

THE foundation-stone of a new technical college for Sunderland has just been laid. The college is to cost 25,000*l.*, and will, it is hoped, eventually be affiliated to Durham University.

DR. C. B. DAVENPORT, of Harvard University, has been appointed professor of zoology at the University of Chicago, in the place of Prof. Wheeler, who has gone to the University of Texas.

MR. H. B. KNOWLES has been appointed principal of the Swindon and North Wilts Technical School. Hitherto he has been teacher of physics and electrical engineering at the Bradford Technical School.

THE Technical Instruction Committee of the West Riding (Yorks.) County Council have consented to financially assist the managers of the district technical schools in forming reference libraries on the subjects of local instruction.

MR. EMERSON E. MCMILLIN has given the Ohio Academy of Science 250 dollars with which to carry on scientific investigations, and declared his intention of giving a similar amount annually if the money is wisely expended.

DARTMOUTH (U.S.A.) COLLEGE has recently received from Mr. E. Tuck, of New York, 300,000 dollars, to be used for the purposes of instruction, and Tuft's College has had bequeathed to it the sum of 60,000 dollars by the late Mrs. M. D. Goddard, of Newton, Mass.

THE regents of the University of California have accepted the plans designed by M. Bénard, of Paris, for their new university buildings, and some of the buildings will, it is stated, be begun next spring. The movement, as will be remembered, is mainly due to the generosity of Mrs. Phœbe A. Hearst.

AT a meeting held at Newcastle on Monday last, it was decided to make an effort to raise funds for the completion of the buildings in connection with the Durham University College of Science. Subscriptions amounting to 9500*l.* were promised at the meeting, and the sum of 100,000*l.* will, it is hoped, be raised by the end of the year.

IN connection with the Liverpool University College, Mr. W. Rathbone has made provision for the award annually of a Rathbone medal to the most distinguished third-year student. Mrs. George Holt and Miss Emma Holt (to whom the College has on more than one former occasion been much indebted) have each given the sum of 5000*l.* towards the physical laboratories of the institution.

AMONG recent appointments abroad we notice the following:—Dr. S. Avery to be professor of chemistry in the University of Idaho; Mr. H. B. Ward to be professor of zoology at Nebraska University; Mr. P. Field to be professor of mathematics in Carthage College; Dr. E. O. Sisson to be director of the histological laboratory in the recently consolidated medical schools of Keoduk, Iowa.

WITH reference to a recent note in this column respecting the admission of women students to the course of study at the Owens College which would qualify them for medical degrees and practice, we are requested to state that the resolution in favour of the course adopted was carried by a majority of nineteen, the voting being twenty-one for the resolution and two against it.

THE promoters of the Birmingham University scheme have recently received the munificent donation of 20,000*l.* from Mr. Charles Holcroft, and a number of large sums from other gentlemen, which bring the total amount promised to upwards of 315,400*l.* The total of over 300,000*l.* having been reached, the committee have secured the last 12,500*l.* which was offered by the friend of Mr. Joseph Chamberlain who prefers to remain anonymous.

## SCIENTIFIC SERIAL.

*American Journal of Science*, October.—Explosive effect of electrical discharges, by J. Trowbridge, T. C. McKay, and J. C. Howe. The authors investigated the sudden increase of pressure in the gas, through which the discharge passes, by means of a vacuum tube provided with a manometer gauge. When spark-gaps up to 50 cm. were employed, with a maximum difference of potential of three million volts, they found that the explosive effect increased closely in proportion to the length of the spark, and began to diminish when the spark was longer than 50 cm. The air itself then becomes a fairly good conductor, and is strongly ionised.—Colour vision and the flicker photometer, by O. N. Rood. The author's flicker photometer reveals the fact that the curve of colour vision is not the same in any two persons supposed to have normal sight. Among five persons capable of sustaining Holmgren's worsted test, differences of colour values ranging from 1 to 14 per cent. were found.—Iodometric determination of gold, by F. A. Gooch and F. H. Morley. The authors investigate the effect upon the immediate evolution of iodine brought about by adding varying amounts of water to the gold solution before introducing the

iodide, and the effect of different amounts of iodide at different dilutions.—Mineralogical structure and chemical composition of the Trap of Rocky Hill, N.J., by A. H. Phillips. The Rocky Hill trap, from its holocrystalline nature, would be classed as a dolerite. From the character of the decomposition of the olivine, and the solution cavities in the diallage crystals, the intrusive nature of this dike is evident, as it must have been formed at a considerable depth below the surface and under very heavy pressure.—Some analyses of Italian volcanic rocks, by H. S. Washington. This paper deals with the composition of trachytes of the Phlegrean Fields and of Ischia. There are three parallel volcanic lines in the Italian district. The latest, along the peninsula, is characterised chiefly by high $K_2O$, by high CaO, and the presence of leucite. The next, that of the islands along the west coast, is high in alkalis, but with $Na_2O$ rather higher than $K_2O$, and without leucite. The third, which lies far out in the Mediterranean, and which is possibly the oldest, is much higher in soda, and seems to be characterised by the presence of peculiar soda minerals such as enigmatite and ægirine, nepheline also occurring in places.—Thermo-electricity in certain metals, by L. Holborn and A. L. Day. This is an English version of the author's Reichsanstalt paper on the gas thermometer.

## SOCIETIES AND ACADEMIES.

### PARIS.

Academy of Sciences, October 9.—M. van Tieghem in the chair.—On the elastic equilibrium of a rectangular plate, by M. Maurice Lévy.—Some remarks on double integrals of the second species in the theory of algebraic surfaces, by M. Émile Picard.—On a modification of Bessel's method for calculating occultations, by M. L. Cruls. In the modification suggested use is made of the time of apparent conjunction of the two stars. The advantage resulting from this method is twofold: it gives by a single calculation a precision generally only obtainable by a second approximation, and lends itself easily to a graphical construction and a simple geometrical interpretation of the different elements upon which the conditions of the phenomenon depend.—Observations of the Giacobini Comet (1889 *e*) made at the Observatory of Besançon, by M. P. Chofardet. The observations were made on the nights of October 3 and 4 The comet had the appearance of a nebulous sphere, 1′ in diameter, and having a slight nucleus of about the 13th magnitude.—On fundamental functions and on the development of a holomorphic function at the interior of a contour in a series of fundamental functions, by M. Renaux.—On the stereochemistry of nitrogen, by M. J. A. Le Bel. The author replies to various criticisms by van 't Hoff, Markwald and others on his work published in 1891 on the preparation of active compounds from methyl- ethyl- propyl-isobutylammonium chloride, and lays down the exact experimental conditions necessary to repeat his results. The conclusion is drawn that there can now be no doubt as to the optical isomerism existing in the derivatives of ammonium chloride containing four different radicles, and containing at least ten atoms of carbon. It is also established that with derivatives less rich in carbon the stability of these optical isomerides is diminished.—On the reversible liquefaction of albuminoids, by M. Tsvett. It is known that the solution of albuminoids is favoured by certain acids, alkalis, and salts. The author has found that certain organic substances, such as resorcinol, pyrocatechol, phenol, chloral hydrate, &c., possess this liquefying property to a very marked extent. Thus a solution of gelatine treated with an eighty per cent. aqueous solution of resorcinol, forms two liquid layers, the upper a solution of gelatine in aqueous resorcinol, the lower a solution of aqueous resorcinol in gelatine, the coefficients of reciprocal solubility varying with the concentration of the resorcinol and the temperature. The phenomenon appears to be truly reversible.—On the volumetric estimation of quinones derived from benzene, by M. Amand Valeur. The quinones are reduced by a mixture of potassium iodide and hydrochloric acid, and the liberated iodine titrated with sodium thiosulphate. Experiments were carried out with quinone, dichloroquinone, toluquinone, and thymoquinone; the results are quite satisfactory, and are very rapidly obtained.—On the structure of the nucleus in the myelocytes of Gasteropods and Annelids, by M. Joannes Chatin. The myelocytes of these invertebrates, contrary to the usual statements, may show a very clear, nuclear membrane.—On the alternation of generations in *Cutleria*, by M. C. Sauvageau.—On a gutta-percha plant capable of being cultivated in a temperate climate, by MM. Dybowski and G. Fron. The authors have extracted gutta-percha from the fresh leaves of *Eucomia ulmoides*. This plant can be grown in temperate climates, and experiments were carried out as to the best mode of multiplication of the plant. It is easy to obtain good seeds in large quantity, but their germination is difficult and capricious. Propagation through cuttings, however, offers no difficulties, the slips taking root easily and developing vigorously.—Action of anæsthetic vapours upon the vitality of dry and moist seeds, by M. Henri Coupin. The vitality of dry seeds is unaffected even by saturated ether and chloroform vapours; but with moist seeds the case is quite different, the presence of only 3·7 c.c. of ether in 10 litres of air being sufficient to kill the seed.

## DIARY OF SOCIETIES.

*THURSDAY*, OCTOBER 19.

CAMERA CLUB, at 8.15.—Clouds and Photographic Landscapes: J. Cadett.

*TUESDAY*, OCTOBER 24.

ROYAL PHOTOGRAPHIC SOCIETY, at 8.—Wellington Film: Harry Wade

*FRIDAY*, OCTOBER 27

PHYSICAL SOCIETY, at 5.—The Magnetic Properties of the Alloys of Iron and Aluminium: Dr. S. W. Richardson.—Exhibition of a Model illustrating a Number of the Actions in the Flow of an Electric Current: G. L. Addenbrooke.—Repetition of some Experiments with the Wehnelt Interrupter devised by Prof. Lecher: W. Watson

INSTITUTION OF MECHANICAL ENGINEERS, at 7.30.—The Incrustation of Pipes at Torquay Water Works: William Ingham.—A Continuous Mean-Pressure Indicator for Steam Engines: Prof. William Ripper.

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THURSDAY, OCTOBER 26, 1899.

## THE INTERNATIONAL ASSOCIATION OF ACADEMIES.

OF late there has been much activity in matters which require the co-operation of scientific men of different nationalities. The International Catalogue of Scientific Literature has been the subject of several conferences. The International Meteorological Conference and the Bureau International des Poids et Mésures are samples of different types of organisations which are both numerous and useful.

The exchange of courtesies at Dover between the British and French Associations for the Advancement of Science gave another proof that cosmopolitanism is growing in strength in the scientific world, and can assert itself even when the political atmosphere is not unclouded.

A still more striking instance of the same fact will be found in the account which we give in another column of a conference at which the possibility of founding an International Association of the great Academies of the world was discussed by their representatives.

The details of the plan are, we believe, still under consideration, but enough has been done to make it practically certain that the Association will be founded, and that the Royal Society, the Academies of Science of France, of Berlin, St. Petersburg, Vienna, Rome, Washington and other similar bodies will be brought into formal relations with each other. It is, no doubt, open to pessimists to say that international meetings are now too numerous, but we venture to think that the proposal to bring about formal conferences between the principal scientific bodies in the world is most important, and that the meetings are likely to lead to more permanent results than do gatherings (also useful in their way) from which the picnic element is not altogether eliminated.

On the other hand, an Association of Academies will be a more flexible instrument for good than are international organisations appointed for specific purposes, and composed either of persons named by the Governments of the countries represented, or of officials controlling national observatories.

The Committee of the Bureau International des Poids et Mésures in Paris and the Geodetic Conference at Berlin are examples of bodies which are entrusted with strictly defined duties, and cannot travel outside the lines laid down for them by their respective Governments. A union of Academies would, however, bring about the meeting at stated intervals of representatives of science, who would not be fettered by the official ties which must necessarily restrict the action of Government nominees. It would thus be possible for the associated Academies to discuss questions connected with any branch of science which might in their opinion call for international co-operation, and if they decided that such action was desirable, to take steps to call the attention of the scientific world or of the various Governments to the necessity for united action.

The Association would, in fact, enjoy the same freedom as the Council of the Royal Society, while it would be able to bring to bear on any question the mature opinion of representatives of the whole scientific world.

It is obvious that an Institution founded on these lines may become of the very first importance, and may play the part of an international parliament of science. Whether or no such a hopeful forecast is realised, it cannot but be useful that the centres of scientific organisation in different countries should themselves be organised, and should be united—not merely by common interests, or by the bonds of friendship which have been established between many of their members—but by formal links which will enable them to take united action when such action is required.

As some of the foreign Academies are concerned with literature and philosophy as well as with natural science the Association will be based upon the same lines. The two sections into which it will be divided will, however, be almost entirely independent, and no serious difficulty need be anticipated on this score. It is, however, curious that though both of the great Anglo-Saxon nations possess important societies concerned with the cultivation of different branches of literature, history or philosophy, neither of them has developed an institution the breadth of whose aims would warrant its inclusion in a list of Academies of literature. It will be unfortunate if this fact makes the literary section of the new Association less truly representative than that which will be concerned with natural science.

"An academy quite like the French Academy . . . we shall hardly have, and perhaps we ought not to wish to have it," said Matthew Arnold, but it will be interesting to see if the foundation of an International Association of Academies leads to a rearrangement of existing organisations which might give us in England something corresponding to the "Académie des Inscriptions et Belles-Lettres," or to the "Académie des Sciences Morales et Politiques."

## A PIONEER IN TELEGRAPHY.

*The Life Story of the late Sir Charles Tilston Bright; with which is incorporated the Story of the Atlantic Cable and the First Telegraph to India and the Colonies.* By his Brother, Edward Brailsford Bright, and his Son, Charles Bright. Pp. xix + 506, and xi + 701. (Westminster: A. Constable and Co.)

TWO books have recently appeared dealing with telegraphy from shore to shore, the one on "Submarine Telegraphs" from the pen of Mr. Charles Bright alone, the other the two-volume treatise now under review. Both are somewhat lengthy, the former because the description of "Submarine Telegraphs" was so much bound up with details concerning the life of Sir Charles Bright, and the latter because to the "Life Story of the late Sir Charles Bright" has been added so much about the history of submarine telegraphy.

Leaving the accounts of the ancestors of this family which are given in rather bewildering detail, we come to the boyhood and youth of the two brothers Charles and Edward. Charles at fifteen, and Edward at sixteen, entered the service of the Electric Telegraph Company soon after its formation in 1847, and started on their careers as inventors. In 1849 they devised a method

for enabling the position of a fault on a telegraph line to be ascertained electrically by the use of resistance coils. In two more years they both left the Electric Telegraph Company, and joined other companies which had started as rivals of this company and of one another, viz. the British Telegraph Company, to which Charles became the assistant engineer, and the Magnetic Telegraph Company, with which Edward associated himself.

But it was the ingenuity and energy which the subject of this memoir displayed in laying the telegraph wires under the streets of Manchester that first brought him into prominent notice. In one night the many gangs of navvies under his superintendence had the streets up, the lower halves of cast iron tubes laid down, gutta-percha covered telegraph wires (wrapped into ropes with tarred yarn) unwound off drums into this iron channel, the two halves of the tubes placed in position, the trench filled up, and the pavement laid down before the inhabitants were out of their beds in the morning.

This account reads like that of a cutting-out expedition of a young Nelson, or a surprise attack of a youthful Wellington, and such an exploit hardly seems possible in the case of the County Council scholar of the modern day, full, it is true, of facts and knowledge, but who has devoted so much attention to learning off what other people have thought out, that he has never had time to find out what he thinks himself, and the bent of whose activity seems to be directed to begging his numerous teachers to give him a sheaf of testimonials and to furnish him with a post.

We can also recommend the study of this exploit of the nineteen-year old Bright to the notice of the local authorities of London from another point of view. In entire oblivion apparently of the fact that the traffic in our streets is not only as great as it was half a century ago, but has become one of the most perplexing difficulties of the present time, and probably in ignorance also of the fact that the developments that have taken place during the past ten years in electric lighting have supplied facilities for carrying on night work in the streets such as were not dreamt of fifty years ago, Bumble still lays long lines of pipes under Fleet Street, Holborn, and the Strand, on what may be called the one man, one boy and a donkey-cart method. And further, since it is generally during the height of the London season that the streets remain broken up for days at a time, we presume that the local authorities are labouring under some delusion that the navvy periodically spends his autumn away from town—say in Switzerland—and is, therefore, only available as an obstructionist about the month of May.

The cable to Ireland having been successfully laid in 1853, attention began to be turned to connecting Great Britain with America. The Atlantic Telegraph Company was consequently formed, but without advertisements or a board of directors, without brokers, commissions, executive officers, promotion money, or even a prospectus. What a striking contrast to the present philanthropic efforts of the "vendor" to benefit the world, and the anxiety of the "scientific expert" to give wide publicity to the extraordinary efficiency of everything that is brought to his notice—professionally.

Considerable vagueness existed at that period as to what the speed of sending messages through a submarine cable really depended on; the memoir states that Sir Charles Bright advocated the employment of a thick copper conductor, weighing $3\frac{1}{2}$ cwt. per mile, surrounded by a coating of gutta-percha having the same weight, but that Faraday, Morse and Whitehouse did not understand the problem properly, and therefore that they opposed Bright's proposal to use a large conductor for the reason that the electric capacity of the cable would be thereby made large, and as, therefore, a large amount of electricity would be required to charge it at each signal the speed would be slow. Lord Kelvin in his Royal Society paper pointed out that the retardation depended neither on the capacity alone nor on the resistance of the conductor alone, but on the product of the two; and so made the whole theory clear—at least made it clear to those who were able to appreciate what a Fourier series could possibly have to do with telegraphing to America.

But economical counsels prevailed, and the copper conductor of the actual Atlantic cable weighed only 107 lbs. a mile, and the gutta-percha coating 261.

The account of the laying of the first Atlantic cable is stirring, thanks partly to the long extracts from the graphic and exciting descriptions which were published by Mr. Nicholas Woods in the *Times*. Numerous were the attempts to lay this cable, and, although they were at last crowned with success—in so far that an Atlantic cable was completed in August 1858, and several messages were actually sent through it—this cable had but a very brief life, one of only three short months in fact.

Numerous arguments are adduced to prove that the causes which led to its break-down all arose from one reason, viz. that the directors did not take the advice of Sir Charles Bright. But, although it is undoubtedly true that the subject of the memoir was an exceptionally able, enthusiastic and energetic man, the contention that if only his advice had been followed the 1858 Atlantic cable would have been a permanent success is not quite so obvious.

For example the use of a powerful induction coil to work a long cable, which is so properly denounced in the body of the book itself, and to which the speedy death of the first Atlantic cable was undoubtedly, at any rate in part, due, was actually resorted to by Sir Charles in his experiments on ten separate lengths of underground wire, joined up to make a total length of two thousand miles, as described in his remarks at the Institution of Civil Engineers in 1857, and quoted in Appendix v. of the book under review. And the successful results obtained with these induction coils "thirty-six inches in length and excited by a powerful Grove battery of fifty pint cells," were advanced as a reason why "he could not see what there was to prevent the working, successfully, through a direct line of two thousand miles" such as an Atlantic cable.

Again, the folly of the Atlantic Telegraph Company in not adopting the larger dimensions which Sir Charles Bright desired to give to the first Atlantic cable is not so evident, since the 1865 cable, which possessed these dimensions, had to be abandoned—broken, after many

unsuccessful attempts had been made to lay it—and in the following year, some months after it had been recovered and completed, both it and the new 1866 cable broke, while one of them broke again the following year.

The fact is that to construct an Atlantic cable at all in those days was a very courageous thing to do; to lay it successfully, even with many failures, evinced a faith and confidence in engineering skill and a dogged spirit of determination that make one proud of the Anglo-Saxon race. To every one who took a prominent part in the enterprise, as certainly did Sir Charles Bright, all honour is due as well as the thanks, not only of his contemporaries, but of all who have followed him.

But we are inclined to think that the authors of this memoir would have been well advised had they not allowed their reverential memory for the brother of the one and the father of the other to lead them to adopt the painter's only method of representing a bright light, viz. by intentionally throwing the rest of the picture into shade.

Volume ii. deals with the telegraph to India, Sir Charles' parliamentary life, the West Indian cables, Sir Charles' work in connection with mining, fire alarms, telephony, electric lighting, the Paris Electrical Exhibition of 1881, the Institution of Electrical Engineers, Freemasonry, and concludes with various appendices.

This life-story is distinctly interesting, but its interest would have been even greater had the matter been compressed into about half, or at any rate into not more than two-thirds, the space. Before a second edition appears we would suggest that such scientific crudities as the following should be altered:—"A current which was estimated by the experts to amount to about 2000 volts." "In the absence of a determinate unit of inductive capacity or quantity of electricity condensers were employed for the first time." "When electricity passes through this surrounding coil of wire, the magnet and mirror take up a position of equilibrium between the elastic force of the silk and the deflecting force of the current. . . . The magnet is artificially brought back to zero with great precision after each signal by the use of an adjustable controlling magnet."

## OUR BOOK SHELF.

*The Maintenance of Solar Energy.* By F.R.A.S. Pp. 20. (London: The Southern Publishing Co., Ltd., 1899.)

THE author of this short essay is not satisfied with the current ideas as to the maintenance of solar energy, but believes his new views tend to remove much of the difficulty. So far as can be judged by these "preliminary notes," however, the theory advanced is one which is not likely to convince any one but its author. Interplanetary water vapour and the periodical indulgence of the sun in cometary vapour baths appear to play an important part, the idea being that as a result of their action the radiant forces of the sun are confined within the limits of the solar system. The recurring absorption of the planets by the sun and subsequent disruption into new systems are other features of a theory which has its principal strength in the fact that there are no means of testing its chief teachings. The author's name does not appear on the title-page, but the preface is signed by J. H. Brown.

*Official Report of the National Poultry Conference held at Reading in July* 1899. Edited by the Honorary Secretaries, Edward Brown, F.L.S., and F. H. Wright, F.S.A.A. Pp. xvi + 138.

THE conference of which this is a report was the first of its kind held in this country, and its success should lead to other similar meetings. The report shows that most of the papers were of a scientific character, and its publication should extend the knowledge of the principles which lead to successful poultry-farming. Among the subjects dealt with are: the science and practice of farm poultry keeping, the parasitic diseases of poultry, and the assistance afforded by science in the production of eggs and poultry. There will be hope for British agriculture when the spirit which pervades these papers guides the operations of all who are concerned with rural industries.

*The Story of Ice in the Present and Past.* By W. A. Brend. Pp. 228. (London: George Newnes, Ltd., 1899.)

AN instructive addition to the "Library of Useful Stories," containing a clearly-written account of the physical properties and geological operations of ice. General readers should find the volume interesting. We notice that the cavities formed by glacier mills are termed "potholes or giant's kettles"; but the former term ought to be restricted to the circular holes found in the beds of streams.

## LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### Effect of Vibration on a Level Bubble.

I HAVE never seen any notice of this phenomenon, but it is sufficiently curious to be worth describing.

I had fitted on a bicycle a small level with a radius of curvature of a foot, in order to note gradients without dismounting. In general this answered very well, and the gradients could be satisfactorily measured with an accuracy of about 1 per cent., but when going over certain classes of rough road (*e.g.* granite paving), the roughnesses of which had a definite pitch, it was noticed that though the road might be level, the bubble would at certain speeds indicate gradients as steep as one in eight or one in six, and remain steadily in such positions as long as the speed and character of the road remained constant. It seemed a matter of chance whether the bubble moved so as to indicate an up or a down gradient.

The explanation is to be found in the coincidence of a natural period of the bubble, due to the surface tension of the fluid, and the interval which elapses between successive encounters of the bicycle wheel with the roughnesses of the road.

Owing to the level being at a certain height above the ground (it was attached to the upper tube of the frame), any pitching of the bicycle, such as is caused by going over rough ground, gives a backward and forward motion to the frame in addition to the general onward movement.

We may suppose, for the sake of simplicity, that this backward and forward motion is a simple harmonic.

When a level is subjected to a harmonic displacement parallel to the mean direction of the tube, the bubble will endeavour at each instant to place itself at that part of the tube where the tangent is at right angles to the resultant of gravity and the imposed acceleration. Thus the bubble tends to move relatively to the tube in the direction of the displacement of the latter, and would always occupy its true position with regard to the resultant if its motion under the variable force was quick enough. The motion of the bubble, however, is very slow compared with that required to bring about this result; but although the forces which act on the bubble have not time to move it far in each period, they do deform it, and the deformation may become

large if the imposed force has the same frequency as any of the natural vibrations of the bubble.

When the bubble is long, as in an ordinary level, the result when such a coincidence is reached is that the long bubble is broken up into a number of small ones, but in the bicycle level the bubble was small and nearly spherical.

The slowest natural vibration which a spherical bubble is capable of is that in which it becomes alternately a prolate and oblate spheroid.

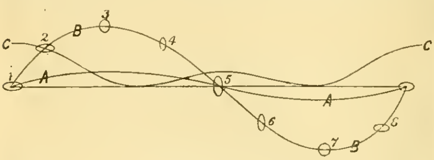
It would take too long to enter in detail into the character of the deforming forces acting on the bubble. They are of two kinds, one depending on the acceleration and the other on the velocity. The former tends to make the bubble egg-shaped (*i.e.* big at one end and small at the other) to a degree proportionate to the acceleration; the latter involves the ratio of the cross section of the bubble and tube, and tends to make the bubble oblate as the velocity increases.

When the impressed motion has the same period as the bubble, the latter will pass through its zero position in opposite phases. Thus, if in moving forwards it is an oblate spheroid as it passes through the zero, it will be prolate half a period later when returning backwards through the same position, but both the deforming force and resistance to motion through the fluid which the bubble experiences when prolate are less than when it is oblate, so that there is a balance in favour of the oblate deformation, which will tend to increase and perpetuate a vibration once started.

Since the resistance experienced by the prolate form is less than oblate resistance, the excursion of the bubble will be greater in the first case than the last, with the result that in time it will move to such a position that the slope of the tube there supplies a force sufficient to balance the difference of resistance met with in moving in opposite directions.

In the accompanying diagram the direction of the level tube is supposed to be at right angles to the abscissa axis, which represents the time of one oscillation.

AA displacement of level tube; BB displacement of bubble relatively to the tube; CC deforming force depending on the velocity; 1, 2, 3, &c., the forms assumed by the bubble at various phases.




There is some particular ratio between the diameters of the bubble and tube, and some absolute diameter of the tube, depending on the surface tension and density of the fluid, which gives the maximum displacement, but even an approximate analytical solution of the problem would present great difficulties.

In the level experimented on, the surface tension of the fluid employed was 27 (in C.G.S.) and density ·88.

The radius of the bubble was ·142 cm. and that of the tube ·23 cm. (rough measurements).

A spherical bubble of the radius given if surrounded by an unlimited quantity of fluid of this surface tension and density would have for the frequency of its slowest natural vibration 120 per second nearly (see Lamb, "Hydrodynamics," p. 463), but in the case under consideration the small distance between the sides of the bubble and tube must greatly diminish the frequency of this form of vibration.

By experiment it was found that the greatest displacement occurred with a frequency between 40 and 50 per second, the bubble then being driven to the ends of the tube where the slope was about one in five.

A. MALLOCK.

3, Victoria Street, October 3.

## Rural Education.

THE Countess of Warwick and Prof. Meldola are entitled to all praise for their zeal in establishing the School of Science at Bigods, to which reference was made in your issue of October 5. There should, however, be some recognition of the similar work done by others in purely rural districts. At Bruton, a village in Somersetshire, the success of such a school has been quite phenomenal. Sexey's Trade School, as it is called, owes its inception to Mr. Henry Hobhouse, M.P., and was founded a few years ago out of the old endowments of Sexey's Hospital under a scheme of the Charity Commissioners, with aid from the Somerset County Council. Recently I had an opportunity of seeing the school, and could not sufficiently admire the excellence of what is done there. The buildings consist of a master's house, large schoolroom and lecture-rooms, well-equipped physics and chemical laboratories, wood and metal workshops, gymnasium, &c., with about two and a half acres of garden and playground attached. Besides instruction in the ordinary subjects of a higher primary or secondary school, the boys in the upper division (Classes II. to V.) are taught magnetism, electricity, chemistry, mechanics, manual work in cardboard, wood and metal, mensuration, French, botany and bookkeeping, and the instruction in technical subjects is throughout of a *practical* nature, being given in the garden, field, and workshops, as well as in the class-room. Outdoor lessons are given in land measuring. Visits are occasionally paid to farms in the neighbourhood to inspect the stock, implements, buildings and crops. Botanical walks are taken at intervals in order to study plants in their natural habits, and the boys are encouraged to make collections of botanical and other specimens.

Since 1896 the school has been organised as a School of Science, and through the courtesy of the headmaster, Mr. Knight, I am able to place the following details before your readers. The fees for tuition are 4*l.* and for boarding 20*l.* per annum. The school has been accepted by the Somerset and Wilts County Councils as one of those at which junior and intermediate county scholars may attend. There are 103 boys at the school, of whom 25 are the sons of farmers, 20 of artizans, and 32 of small tradesmen. Of those who have left the school 34 have taken to farming as an occupation. From the forty-fifth Report of the Science and Art Department it appears that in 1897 the school presented 63 pupils for examination. The grant earned was 384*l.*, being an average of 6*l.* 2*s.* per head. The High School at Middlesbrough stood next on the list with an average of 5*l.* 13*s.* per head, and the general average for the 143 organised Science Schools in Great Britain was 3*l.* 9*s.* 6*d.* Such an experience as this ought to be of the greatest encouragement to those who are really anxious for the improvement of rural education, and the facts cannot be too widely known. This school differs from the one at Bigods in that it is only for boys; but a school is now being erected in the immediate neighbourhood to provide a modern education for girls, corresponding as far as possible with that provided for the boys.

JOHN C. MEDD.

Stratton, near Cirencester, October 15.

THE good work being done at Sexey's Trade School is of course well known to all who have interested themselves in rural education. Readers of NATURE will no doubt be glad to have Mr. Medd's independent testimony, and more particularly the detailed statement of figures concerning grants and fees. At the present time, when the subject of rural education is so very much before the public, it would, however, be of the greatest assistance to those who are engaged in carrying on this work if Mr. Medd could supply more detailed information concerning the aid which the County Council has given and how this assistance has been rendered; whether in the form of grants for building and equipment or for maintenance of staff, or both. Also what proportion of the initial cost of foundation as a School of Science was contributed by the Somersetshire County Council? In the present state of rural education one cannot help feeling that the whole future success of these schools is very largely dependent on the constitution of the Technical Instruction Committees of the County Councils—especially in those cases where the County Council has become recognised as the central authority. Any information, therefore, that can be given on these administrative points, either with respect to Sexey's or any similarly constituted school, would be most opportune. In the case of our school at Bigods, the initial cost of foundation and conversion into a School of Science has been mainly borne by Lady Warwick. The Essex County Council, as regards maintenance of staff, have put us on the same footing as the endowed schools in the county by granting 100*l.* annually.

R. MELDOLA.

## *ON THE DISTRIBUTION OF THE VARIOUS CHEMICAL GROUPS OF STARS.*[1]

SOME few years ago it was my duty to give a course of lectures here relating to the sun's place in nature. I attempted to give an idea of the relation of the sun, as to age and temperature, to other stars, and also its relation to bodies supposed to be of a different order altogether.

Since that lecture was delivered our knowledge on this and allied subjects has advanced with giant strides. We now know, thanks to spectrum analysis, the principles of which I then explained, a great deal of the chemistry of the stars, so much that we can now classify them into groups, defining those groups by the chemical elements involved in each. I shall not bring before you to-night the detailed classification of these bodies, but shall, for the purposes of this lecture, ask you to consider the four following kinds only:

*Highest temperature.*

Gaseous stars { Proto-hydrogen stars.
Cleveite-gas stars.

Proto-metallic stars.

Metallic stars.

Stars with fluted spectra.

*Lowest temperature.*

The table almost explains itself: I may add that by "proto-metallic" stars I mean those stars in the spectra of which the metals we know here are chiefly represented by lines—the so-called "enhanced-lines"—we can only obtain here by using high-tension electricity, and there are other evidences which show that these stars are hotter than the metallic ones, while they, in their turn, are cooler than the gaseous stars. In discussing the work of other observers I have as far as possible transposed the different notations employed into the chemical one given above.

In relation to the sun's place we had a great many comparisons to make with different stars quite independently of their position in space. I propose now to touch upon a still more general inquiry to consider the distribution of all stars in space, not in relation to their magnitudes, but in relation to their chemistry.

It is obvious that we are among the first from the beginning of the world who have been able to do this, because formerly the chemistry of these celestial bodies was entirely lacking. I think, therefore, you will agree that it is a very important thing, now that we have the chemistry, to inquire into the distribution of the various chemical conditions in the different parts of the universe in which our lot is cast. For that purpose, I will deal with the stars as generally as I can, considering only the wider division into the gaseous stars, the proto-metallic stars, that is to say, the stars represented by the enhanced lines, then the metallic stars in which we are dealing with arc lines, and then the metallic fluting stars and the carbon fluting stars. As star-life begins with nebula and meteoritic swarms, it ends with dark stars which it is possible may be very numerous in space. How many there are we do not know, because we cannot see them; but there are reasons for supposing that there is a very considerable number.

We have only to deal with the masses of matter in space which are visible, and it is obvious that any inquiry into the distribution of the chemical conditionings, as revealed by spectra, of these masses must be preceded by an inquiry into the distribution of these masses considered merely as masses and quite independent of chemistry.

This work has already occupied the attention of many eminent astronomers, and I will begin by placing the results of their labours before you as shortly as I can.

I call your attention to the Milky Way. If you have seen the Milky Way from a high mountainous country, as I have done, you will acknowledge what a very wonderful


FIG. 1.—Photograph of a glass globe showing the relation of the Milky Way to the Equator an to Gould's belt of stars.

thing it is; I was most struck with the Milky Way when I was in the Rocky Mountains some years ago. It was not merely the pale milky belt we generally see running across the sky, but it had lights, shades, shadows, brightnesses and dimnesses; it was full of the most marvellous details. I have seen it, I am bound to say, just as well on the coast of Kent, but not often. You want an extremely fine sky to see the Milky Way properly; but, at all events, whether you have seen it well or ill, all of you, I am sure, are familiar more or less with it. What is it? It is a bright belt encircling the heavens; its position with regard to the equator of the earth, and the equatorial plane extended to the stars, I can show you roughly by means of a glass globe. Those who are familiar with Dante know that the old view of the heavens was that the earth was immovable in the

[1] A Lecture to Working Men, delivered at the Museum of Practical Geology, on April 10, by Prof. Sir Norman Lockyer, K.C.B., F.R.S.

centre; that there were several heavens round it: the heaven of the moon, the heaven of Venus, of Mars, and so on, till at last there was a heaven of the stars, a crystalline sphere to which the stars were fixed like golden nails. Let the glass globe represent this crystalline sphere.

The Milky Way is a great circle inclined, at an angle of about 62°, to the earth's equator or to the equatorial plane extending to the stars. We know nothing, of course, of the reason for that angle of 62°, but it has its importance, because not only must the belt cross the equator at two opposite points, as it does in two opposite constellations, Aquila and Monoceros, but the poles of the Milky Way must lie at the points of greatest distance from the junction with the equator, in certain constellations. These are Coma Berenices and Sculptor, and the position of the N. galactic pole, as the pole of the Milky Way is called, is in R.A. 12h. 40m. Dec. + 28°. Now, although the Milky Way looks very unlike the other parts of the heavens, we have known since the time of Galileo that the difference arises from the fact that it is composed of a tremendous multitude of stars; and this is why I have drawn attention to it, a very large percentage of the masses of matter which compose our system lies in the plane of the Milky Way. It does not merely represent a fiery or igneous fluid, as different schools thought it did in the old days. So far as our opera-glasses and telescopes indicate to us, we are in presence of an innumerable multitude of stars. When, however, we come to look at it a little more closely, we find that from two points in it branches are thrown out, so that over some part of its orbit, so to speak, it is double; there is a distinct doubling of the Milky Way along a part of its length. But in spite of that, the middle line of the galaxy or the Milky Way is really not distinguishable from a great circle, as was formerly supposed. The great rift which separates these two parts of it begins near a star in the southern hemisphere, $\alpha$ Centauri, and it continues for more than six hours in right ascension until the two branches meet again in the constellation Cygnus, which is well within our ken in the northern heavens. The distance apart of the middle lines of these two components of the Milky Way where the split is most obvious is something like 17°, so that, in addition to the angle of 62° from the ecliptic, in some part of the Milky Way, there is another offshoot springing out of it at an angle of something like 17°. The regions of greater brilliancy correspond approximately to the places where the branches intersect each other. In short, there are sundry indications that the whole phenomena of the Milky Way may become simplified by treating it as the resultant of two superimposed galaxies. The general view till recently was that the Milky Way is not a great circle, because it was thought the sun was not situated in its plane. The whole mass of stars was likened to a millstone split along one edge, which was Sir William Herschel's first idea. But the recent work, chiefly of Gould in Argentina, has shown that it practically is a great circle. However that may be, in one part of the heavens this wonderful Milky Way appears as a single, very irregular stream, and in another part it appears to be duplicated.

It is impossible in this short course of lectures to attempt to give anything like an historical statement of the growth of our knowledge of the Milky Way. I can only refer you to the Milky Way itself; and the next time any of you have an opportunity of seeing it, just look at the wonderful majesty and complexity of it. We find in it indications of delicate markings going out into space, apparently coming back strengthened, of streams in all directions, of clusters clinging to those streams, and so on. In other parts it is curdled, which is the only term which I can use to express my meaning. In another part we may find it absolutely free from any important stars; in another we may find it mixed with obvious nebula; and in another we may find it mixed, not only with obvious nebula, but with a great number of bright-line stars involved, not only in the Milky Way, but in the nebula itself.

We have now, fortunately for science, priceless photographs of these different regions. One will give us an idea of the enormous number of stars in some parts; another one of the streams of nebulous matter which are seen in the Milky Way from region to region. Again we find a regular river of nebulous matter rushing among thousands of stars. In some the galaxy seems to tie itself in knots. There is an individuality in almost every part of it, which we can study on our photographic plates; practically there are no two parts alike. Others again bring before us the curdled appearance which is visible in different regions, and finally the connection of the infinite number of stars with obvious nebulous matter. In this way, then, we are enabled to form an idea of the general conditioning of things as we approach the Milky Way.

The next important point is that the enormous increase of stars in the Milky Way is not limited to the plane itself, but that there is really a gradual increase from the poles of the Milky Way, where we get the smallest number of stars. It is not very easy to bring together all the information, for the reason that different observers give different measures; they take different units for the space they have determined to be occupied by stars from the pole towards the galactic plane; and also the number of stars in the northern hemisphere is not the same as the number in the southern hemisphere. But roughly speaking we may say, if we represent the number of stars at the galactic pole by four, the number of stars in the galactic plane will be about fifty-four.

The following table will show the gradual increase in the number of stars from the pole to the plane, as seen by the Herschels with a reflecting telescope of eighteen inches aperture and twenty feet focal length :—[1]

| Galactic polar distance. | Average number of stars per field of 15′ | |
|---|---|---|
| | Northern. | Southern. |
| 0-15 | 4·32 | 6·05 |
| 15-30 | 5·42 | 6·62 |
| 30-45 | 8·21 | 9·08 |
| 45-60 | 13·61 | 13·49 |
| 60-75 | 24·09 | 26·29 |
| 75-90 | 53·43 | 59·06 |

A consideration of the distribution of stars in Right Ascension between declinations 15° N. and 15° S. led Struve to the conclusion that there are well marked maxima in R.A. 6h. 40m. and 18h. 40m., and minima in R.A. 1h. 30m. and 13h. 30m.; he remarks that the maxima fall exactly on the position of the Milky Way in the equator, and further states that "the appearance of the close assemblage of stars or condensation, is closely connected with the nature of the Milky Way, or that this condensation, and the appearance of the Milky Way, are identical phenomena."

Although the Milky Way dominates the distribution of stars, and especially of the fainter stars, it does not appear to be the only ring of stars with which we have to do. Sir John Herschel traced a zone of bright stars in the southern hemisphere, which he thought to be the projection of a subordinate shoot or stratum. That was the first glimpse of a new discovery, which was subsequently established by Dr. Gould in his work in the southern hemisphere at Cordova. He found that there was a stream of bright stars to be traced through the entire circuit of the heavens, forming a great circle as well de-

[1] *Outlines of Astronomy*, Herschel, pp. 535, 536.

fined as that of the galaxy itself, which it crossed at an angle of about 25°.

Gould, while in the southern hemisphere, had no difficulty in observing that along this circle, which we may call the Star-way, in opposition to the Milky Way, most of the brighter stars in the southern heavens lie.

When he subsequently came home he made it a point of study to see whether he could continue this line of bright stars among the northern hemisphere, and he found no difficulty. So that we may now say that the existence of this supplementary Star-way, indicated by the line of extremely bright stars, is beyond all question.

I quote the following from what Gould has written on this subject.[1]

"Few celestial phenomena are more palpable there than the existence of a stream or belt of bright stars, including *Canopus*, *Sirius*, and *Aldebaran*, together with the most brilliant ones in *Carina*, *Puppis*, *Columba*, *Canis Major*, *Orion*, &c., and skirting the Milky Way on its preceding side. When the opposite half of the galaxy came into view, it was almost equally manifest that the same is true there also, the bright stars likewise fringing it on the preceding side, and forming a stream which diverging from the Milky Way at the stars $\alpha$ and $\beta$ *Centauri*, comprises the constellation *Lupus*, and a great part of *Scorpio*, and extends onward through *Ophiuchus* towards *Lyra*. Thus a great circle or zone of bright stars seems to gird the sky intersecting with the Milky Way at the Southern Cross, and manifest at all seasons, although far more conspicuous upon the *Orion* side than on the other. Upon my return to the North, I sought immediately for the northern place of intersection; and although the phenomenon is by far less clearly perceptible in this hemisphere, I found no difficulty in recognising the node in the constellation *Cassiopeia*, which is diametrically opposite to *Crux*. Indeed it is easy to fix the right ascension of the northern node at about oh. 50m., and that of the southern one at 12h. 50m.; the declination in each case about 60°, so that these nodes are very close to the points at which the Milky Way approaches most nearly to the poles. The inclination of this stream to the Milky Way is about 25°, the Pleiades occupying a position midway between the nodes."

Gould also had no difficulty in showing that the group of the fixed stars to which I have just referred, at all events of fixed stars brighter than the fourth magnitude, is more symmetrical in relation to this new star line than to the Milky Way itself, and that the abundance of bright stars in any region of the sky is greater as the distance from this new star line becomes less. Practically five hundred of the brightest stars can be brought together into a cluster, independent of the Milky Way altogether—a cluster he points out of somewhat flattened and bifid form.

Not only do we find that the stars are very much larger in number near the Milky Way than elsewhere, but that the same thing happens with regard to the planetary nebulæ. Nebulæ generally, I am sorry to say, I cannot profess to discuss with any advantage, because there are very many bodies classed as nebulæ in the different catalogues about which we know absolutely nothing as to their physical nature. It will be remembered that many years ago the question of the real existence of nebulous matter in space was rendered very difficult by the fact that the larger telescopes, which were then being made by Lord Rosse, brought before us a great number of clusters, the stars of which were so close together that they seemed to form a nebulous patch, whereas on a finer night or with a better instrument we were able to see that we were simply dealing with distant clusters. I do not propose, therefore, to say anything about nebulæ generally, but to call attention to those points about which we can be most certain.

[1] *Amer. Jour. Sci.*, viii. p. 332.

We do know that, not only do we find stars increasing in number as the Milky Way is approached, but the undoubted star clusters also increase towards the Milky Way in a marvellous manner.

Bauschinger[1] (1889) in a review of Dr. Dreyer's New General Catalogue (7840 objects) discussed the distribution of different classes of objects and found that star clusters, by which he means of course resolved clusters, and planetary nebulæ congregate in and near the galaxy.

Mr. Sydney Waters some four years later, in 1893, brought together the nebulæ and the star clusters for us, and I propose to show the very important maps which he drew. He indicates a star cluster by a cross, and nebulæ by round dots. Practically the obvious star clusters are limited to the Milky Way. That is a very admirable way of bringing the knowledge with regard to any one of these distinct groups of stars before us, and it shows us in a most unmistakable manner that the star clusters, like the planetary nebulæ and stars generally, are very much more numerous in the plane of the Milky Way than they are in any other part of the heavens.

It is striking to note the fidelity with which the clusters follow, not only the main track of the Milky May, but also its convolutions and streams, while the remarkable avoidance of the galaxy by the nebulæ, excluding the planetary nebulæ, is obvious, indeed, it was remarked upon by Sir Wm. Herschel.

We have seen, then, that we have the greatest number of stars congregating in the plane of the Milky Way, the greatest number of planetary nebulæ and the greatest number of star clusters. We have next to consider whether any particular kind of a star congregates in the Milky Way or avoids it. In that way we shall be able to see the importance of this new chemical touch, which is now possible to us in our survey of the heavens.

The first attempt at such an inquiry as this was made in 1884 by Dunér,[2] who had made himself famous by his admirable observations on two different classes of stars —those which I have referred to as being defined by carbon flutings in one case and metallic flutings in the other. His work was practically the only research on the carbon stars—the stars, that is, with carbon flutings. He was, naturally, anxious to see how they were distributed, and he gives the number of these stars in varying parts of the heavens in relation to the Milky Way. He found that the numbers increased towards the Milky Way. The table I give will show the general result at which he arrived. We had, as we saw in the case of the ordinary stars, a very rapid progression in number from the pole of the Milky Way to the plane; we had three stars at the pole when we had fifty-three in the plane.

| Dist. from galactic pole. | Number. | Mean mag. |
|---|---|---|
| ° ° 0–35 | 3 | 6·6 |
| 35–60 | 8 | 6·6 |
| 60–70 | 8 | 7·2 |
| 70–80 | 13 | 7·4 |
| 80–90 | 29 | 8·3 |

Dunér found, with regard to his carbon stars, that there was distinctly an increase from the pole towards the plane, but we observe that the rate of increase was very much less in this case; so that, starting with three at the pole, he only found twenty-nine in the plane. Although then it was true that the number of stars did increase towards the Milky Way, they did not increase so rapidly as the stars taken as a whole; still, from his observations, we are justified in stating that

[1] *V.J.S. Ast. Ges.*, xxiv. p. 43.
[2] "Étoiles de la troisème Classe," p. 125.

there is an increase as we approach the plane of the Milky Way. They are, therefore, not limited to the plane. Now we know that these stars are the moribund stars, the stars just disappearing, the stars whose light is waning; so that soon after the carbon stage they exist in the heavens as dark stars, and we can only know their existence by their gravitational effect upon other stars which are self-luminous. It is also to be borne in mind that these stars, just because they are in their waning

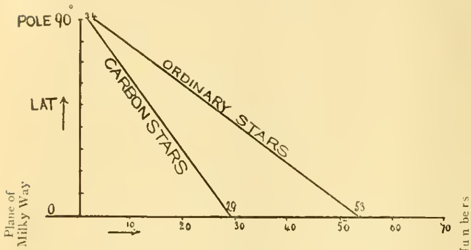



FIG. 2.—Comparison of relative numbers of stars generally and carbon stars.

stage, are very faint; so that the information we are able to get with regard to them may possibly be information concerning their distribution in parts of space not very far distant from that which we ourselves occupy.

That was in 1884. In 1891 Prof. Pickering, when he found that he had collected something like 10,000 stars in the Draper catalogue, began to consider their distribution in different parts of space in relation to the then classification, which was practically a classification founded on hieroglyphics, since we knew very little about the chemistry of the different bodies at that time.

He found that the Milky Way was due to an aggregation of white stars, by which he meant, as we now know, very hot stars, and the hottest of them, that is the gaseous ones, exist more obviously in the Milky Way than do the others. The proportional number of proto-metallic stars in the Milky Way was greater for the fainter stars than for the brighter ones of this kind, and that at once suggests a possibility that in the Milky Way itself there is a something which absorbs light; so that the apparently brightest stars are not actually the brightest, but are more luminous because they have not suffered this absorption, and that those which have suffered this absorption may be very much further away from us than the others of a similar chemistry. He also arrived at this extremely important conclusion, namely, that the metallic stars, that is, stars like our sun, stars more or less in their old age, had no preference for the Milky Way at all, but are equally distributed all over the sky. With regard to the group of stars known by metallic flutings in their spectra, he has no information to give us any more than Dunér had, for the reason that their number is small and they have not yet been completely studied.

Only last year this inquiry was carried a stage further by Mr. McClean, who not only photographed a considerable number of stellar spectra in the northern hemisphere, but subsequently went to the Cape of Good Hope in order to complete the story with reference to the stars down to the third or fourth magnitude, which he could observe there. He was very careful to discuss, in relation to the Milky Way and certain galactic zones, the distribution of the various kinds of stars which he was fortunate enough to photograph.

We notice that if we deal with the gaseous stars the numbers in the north and south polar region are small, and that the numbers nearer the Milky Way are greater, so that finally we can see exactly how these bodies are distributed. If we take the gaseous, that is to say the hottest, stars, we find the smallest number in the polar regions; but if we take the metallic stars we find practically the largest number, at all events a considerable number, in the polar regions. The general result, therefore, is that the gaseous stars are mostly confined to the galactic zones, the proto-metallic stars are not so confined, that is to say, down to about $3\frac{1}{2}$ magnitude. What is also shown there is that the metallic-fluting stars are practically equally distributed over the polar regions and over the plane of the Milky Way itself: so that, in that respect, we get for these stars very much the equivalent of the result arrived at by Dunér, that is to say, they have little preference for the Milky Way.

*(To be continued.)*

## *THE PARENT-ROCK OF THE SOUTH AFRICAN DIAMOND.*[1]

DIAMONDS were discovered in gravels of the Orange River in 1867, and were traced three years later to a peculiar earthy material called from its colour "yellow ground" by the miners. This, which was soon found to pass down into a more solid and dark-coloured material called "blue ground," occupies "pipes" in the country rock—carbonaceous shales and grits belonging to the Karoo system; the one standing in much the same relation to the other as do the volcanic necks to the carboniferous strata in Fifeshire. Flows or sills of basaltic rocks are associated with the sedimentary strata, and both are cut by dykes. The matrix of the blue ground is a fine granular mixture, chiefly consisting of a carbonate (calcite or dolomite) and serpentine. In this are embedded grains of garnet (mostly pyrope), pyroxenes (a chrome diopside, smaragdite or enstatite), a brown mica, magnetite and other ores of iron, and some other minerals more sparsely distributed. Rock fragments also occur; some of them are the ordinary shale and grit, but others are compact and of an uncertain aspect. Crystalline rocks are sometimes found.

As to the nature of this blue ground and the origin of the diamond, very diverse opinions have been expressed. The late Prof. Carvill Lewis considered the former to be a porphyritic peridotite, more or less serpentinised, which sometimes passed into a breccia or a tuff, and the diamond to have been formed *in situ* by the action of this very basic igneous rock upon the carbon present in the Karoo beds. Others, however, maintained that the rock was truly clastic; being produced by the explosive destruction of the sedimentary rocks, together with part of their crystalline floor—was, in fact, a kind of volcanic breccia, subsequently altered by the action of percolating water at a high temperature. But they also differed in opinion as to the genesis of the diamond itself; one party holding it to have been formed *in situ*, by the action of water at a high temperature and pressure, the other considering it, like the garnets, pyroxenes, &c., to have been formed in some deep-seated holocrystalline rock mass, and to have been set free, like them, by explosive action.

A few months ago the investigation had advanced thus far: (1) study of the diamonds obtained from the blue ground had increased the probability of their being derivative minerals; (2) no certain proof of the former existence of a compact or glassy peridotite had been discovered; (3) certain compact rock fragments, as to the origin of which the writer had at first hesitated to express an opinion, had been determined by him to be only argillites, affected first by the action of heat, then of water; (4) the diamond and the garnet had been brought into very close relation by the discovery of two specimens, showing the former apparently embedded in the latter. The better of them was accidentally picked up at a depth of about 300 feet in a shaft at the Newlands Mines, West

[1] The substance of a paper read before the Royal Society on June 1.

Griqualand (about forty-two miles to the north-west of the more famous group in the neighbourhood of Kimberley). In this specimen a rather large and irregularly shaped pyrope projects from one end of a fragment of blue ground: one small diamond is embedded in this pyrope, and five others either indent it or are in close contact. Fortunately the discoverer was the managing director of the company, Mr. G. Trubenbach, who appreciated its importance, and so kept a sharp look-out for anything remarkable which might turn up during the excavations. Accordingly he preserved specimens of certain boulders, sometimes over a foot in diameter, well rounded and just like stones from a torrent, which occasionally occurred in the blue ground at various depths down to 300 feet. Several of these contained garnets, being varieties of eclogite, but diabase was also obtained.[1] Some of these Mr. Trubenbach brought to London, and on the outer surface of one a small diamond was detected. The boulder was broken, and others were exposed. A fragment (rather less than a third) was sent to Sir W. Crookes, who entrusted it for examination to the writer, and to him Mr. Trubenbach afterwards sent other boulders, besides rock and mineral specimens, with the permission of the directors.

In addition to the boulder of diabase, which has no special interest beyond the fact of its occurrence, there are six boulders of eclogite (one perfect, the rest having been broken), all but one (which may have been four or five inches long) measuring a foot across, more or less. Three of these consist almost entirely of a garnet (pyrope) and an augite (chrome diopside), the former varying in size from a large pea downwards, and the other mineral corresponding. The pyrope is often surrounded, especially towards the exterior of the boulder, by a "kelyphite rim" consisting mainly of a brown mica. This and a few other minerals were present elsewhere, but in very small quantities. The remaining three boulders consisted of the same two constituents, with the addition of a considerable amount of a variety of bastite and a few flakes of brown mica. Of the first group of specimens two contain diamonds, the first-named having at least nine and another certainly one, perhaps a second. All are small, the largest being about ·15 inch in diameter. They are well-formed octahedra, with slightly stepped faces, perfectly colourless, with an excellent lustre. Evidently they are just as much an accidental constituent of the eclogite as a zircon might be of a granite or syenite.

This discovery leads to the following conclusions. As the diamond is found in boulders of eclogite, and these are truly water-worn, that rock is the birth-place, or at any rate one birth-place, of the diamond (for its occurrence in a more basic species, such as a peridotite, may be expected). Hence the diamond is not produced in the blue ground, but is present in it as a derivative from older rocks, in the same way as the olivine, the garnets, the various pyroxenes, &c. Moreover, the blue ground is a true clastic rock, and not a serpentinised peridotite of any kind, so that the name Kimberlite, proposed for it by Prof. Lewis, must disappear from that group. The rock is a volcanic breccia, though a rather peculiar one, for scoria has not yet been detected in it. Probably it was formed by explosions due to pent-up steam, the vents being driven through the upper part of the crystalline floor and the overlying sedimentaries. These never ejected lava, and were soon choked up with shattered material. Through this, in all probability, steam or heated water continued to be discharged for a considerable time, which accounts for the marked changes effected in the exterior of the larger fragments and in the more finely pulverised material of the matrix.

T. G. BONNEY.

[1] The occurrence of boulders in the blue ground at De Beers Mine was asserted by Stelzner in 1893 (*Sitzungber. u. Abhandl. der Isis*, 1893, p. 71).

## NOTES.

WE are informed that copies in bronze of the medal presented to Sir G. G. Stokes at his jubilee can now be obtained from Messrs. Macmillan and Bowes, Cambridge, price 15*s*. each.

AT the opening meeting of the new session of the Institution of Civil Engineers, on November 7, an address will be given by the president, Sir Douglas Fox, and the prizes and medals awarded by the Council will be presented.

A GOLD medal is offered by the Cercle industriel agricole et commercial, Milan, for the description of a method, or the construction of apparatus, which will assist in the prevention of accidents to artizans engaged in electrical work.

A CONVERSAZIONE of the Geologists' Association will be held in the library of University College on Friday, November 3. A number of pictures and objects of geological interest will be on view during the evening.

THE Allahabad *Pioneer Mail* (October 6) states that Mr. Douglas Freshfield has started from Darjeeling, with a party of friends and Alpine guides, to explore the glaciers and little-known passes of the Kanchenjunga range. The exact course to be pursued is probably unknown to the party themselves, who must be guided by circumstances; but any addition to the scanty and inaccurate information at present extant on the subject of the Himalayan giant will be welcome to geographers.

IT is stated that another British exploring expedition to Abyssinia has been arranged, and will leave England at once. The members are Mr. James J. Harrison, Mr. Powell Cotton, Mr. W. Fitzhugh Whitehouse (of Newport, Rhode Island) and Mr. A. E. Butter. Mr. Donald Clarke will go as surveyor and geographer, and a taxidermist will also accompany the party. The objects of the expedition are scientific and sporting, and it is expected that the journey will occupy about nine months.

THE thirty-eighth annual general meeting of the Yorkshire Naturalists' Union is to be held at Harrogate to-day, and an address upon the evolution of plants will be given by Mr. William West, the retiring president. The Union is a model of a well-organised local society, which not only serves to develop interest in science, but also assists in the extension of natural knowledge. The membership is not in any way commensurate with the importance of the work carried on, and we are glad to see that efforts are to be made during the forthcoming winter to bring the claims of the Union for support before the naturalists and the public of the County of York.

THE *British Central Africa Gazette*, published at Zomba, always contains several items of scientific interest, and the latest number received, dated August 24, is not deficient in this respect. We learn from this source that Mr. J. E. S. Moore has been taking soundings at the north end of Lake Nyasa. Off Ruarwe a depth of 418 fathoms was found, and off the higher parts of Livingstone Range bottom was reached at 210 fathoms.—Mr. Poulett Weatherley describes in a letter a difficult journey up the Luapula, and through its innumerable rapids. The Luela is regarded as the second most important tributary of the Luapula, but there is little to choose between the Luombwa, the Luela, the Mwyangashe and the Luongo, though the Luombwa is the largest and most delightful of the four.

REUTER'S correspondent with Major Gibbons' trans-African expedition reports from Lialui (Barotsiland), in a despatch dated August 5, that much valuable exploring work had been done by the members of the expedition. The routes traversed by the travellers since last January amount in the aggregate to 3500 miles, mostly through unknown or unexplored districts.

The plans of the party at the date of the despatch are reported to have been as follows:—At the end of this month Captains Quicke and Hamilton will travel east to the Kafukwe, while Major Gibbons will make a journey up the Zambesi with canoes to Nanakandundu, returning by river as far as the Kabompo confluence, whence he will make a line to the Kafukwe. Captain Hamilton will then travel down that river to its confluence with the Zambesi, where an aluminium boat awaits him, in which he will descend the river to Zumbo, and return home *via* the east coast. Major Gibbons with Captain Quicke will travel up the Kafukwe, and, after following the Zambesi from its source to Nanakandundu, will make for St. Paul de Loanda on the west coast. All three hope to reach the coast in December by their respective routes.

THE long-standing question as to the admittance of women into full fellowship of scientific societies was brought before a meeting of the Lady Warwick Agricultural Association for Women on Thursday last, and the following resolution, supported by a paper by Mrs. Farquharson, was adopted: "That it is desirable and important that duly qualified women should have the advantages of full fellowship in scientific and other learned societies, *e.g.* the Royal, the Linnean and the Royal Microscopical." The arguments in favour of and in opposition to this proposal have been stated so many times that most members of scientific societies are familiar with them. Six years ago the Council of the Royal Geographical Society elected several ladies as fellows, but their action was disapproved at two special meetings, and resolutions to the effect that it was inexpedient to admit ladies as ordinary fellows were carried by conclusive votes. Ladies are, however, admitted to the meetings of the Society, and papers are accepted from them. In the case of the Royal Astronomical Society, ladies are only admitted to the ordinary evening meetings by special invitation of the president, sanctioned by the Council, the invitations being issued at the commencement of each session. The time may of course come when women will be equally eligible with men for membership of the learned societies, but facts such as those cited show that there is distinct opposition to the admittance of women at present, and no sudden change of feeling can be expected, though individual cases of "duly qualified" women might be considered.

IN a review which appeared in NATURE of September 7 (p. 433), reference was made to the hair of a "Panyan woman," figured as a "Negrito type, India," in Prof. A. H. Keane's work on "Man, Past and Present." Mr. Thurston's original photograph, from which the illustration was reproduced, shows the hair of the woman as of a distinctly curly character, "which feature," the writer of the review remarked, "is unfortunately lost in Keane's reproduction." Prof. Keane writes to say that his picture is a facsimile of Mr. Thurston's photograph, and shows the curly hair portrayed in the original. In support of his case he has submitted the portrait and the reproduction to us, and we must confess our inability to distinguish any obvious difference between them. The writer of the notice maintains, however, that the hair is not quite the same in the two, and he unites with Prof. Keane in the hope that every one interested in the matter will compare the illustrations for themselves before accepting either view.

DR. C. LE NEVE FOSTER reports, in a Blue Book just issued ("Mines and Quarries: General Report and Statistics for 1898," part iii.), that the total value of all minerals raised in the United Kingdom in 1898 exceeded 77,000,000*l.*, being an increase of five millions compared with the previous year. The output of coal during the year exceeded 202 million tons, of which 36½ million tons were exported. This large export of coal induces Dr. Foster to call attention to the plain warning contained in Mr. T. Forster Brown's paper on "Our Coal Supplies" (*Journal* Society of Arts, 1899, p. 508), in which it is emphatically stated that in another fifty years the dearth of cheap coal will begin to be felt. Referring to this, Dr. Foster says: "We are already dependent upon foreign countries for much of our iron ore, and it will be an evil day when we feel the pinch of poverty in coal. The proper husbanding of the coal resources of the kingdom is therefore a question of national importance."

THE great success of the installations for the development of electricity by power obtained from Niagara Falls is naturally leading enterprising capitalists in many other parts of the world to consider similar projects. We learn, for instance, from the *Pioneer Mail* that within the last few months schemes have been ventilated for utilising the Nerbudda at the Marble Rocks for supplying power to the new gun-carriage factory to be erected near Jubbulpore. There is also a project for running the Kashmir railway by electricity, the power being taken from the Chenab. Then there is another plan for supplying electrical power to Murree, deriving the energy from the Jhelum, which runs within ten or twelve miles of that sanatorium. For Simla there are no less than two schemes for obtaining electrical power by hydraulic means: one from the Sutlej, and another from a proposed lake to be made in the nullah below the station. Assuming that the majority of these schemes are practical, the point which remains somewhat obscure for the present is whether the demand for electricity in any of the places named would be sufficiently great to make the undertaking a commercial success.

THE *Experiment Station Record* (No. 5) of the U.S. Department of Agriculture contains a description of the biological and dairy building recently completed by the New York State experiment station at Geneva. The building has been constructed and equipped by the State for the study of dairy problems, and especially those concerned with cheese-making. The changes which take place during the curing of cheese, and the conditions which influence them, are still so imperfectly understood that the work carried on in the new laboratories is sure to lead to valuable results. Arrangements are provided for studying the ripening process in all its phases; and a bacteriologist is attached to the staff.

A NUMBER of excellent photographs obtained with a telephoto lens, by Mr. D. L. Elmendorf, are reproduced in the current number of *Scribner's Magazine*. A telephoto attachment, consisting of a negative lens, with a rack and pinion mounting, was used upon an ordinary rectilinear lens to take the pictures. With this attachment eight inches from the plate, the image obtained was equal to that formed by an ordinary lens of twenty-four inches focus; while at twenty-four inches from the plate, this being the greatest extension of the camera employed, the combination was equivalent to a lens of sixty-four inches focus. Among the striking pictures which accompany Mr. Elmendorf's article are views of the Jungfrau, obtained at a distance of sixteen miles, and of the cone of Popocatepetl, Mexico, taken at a distance of thirty miles.

THE Pilot Chart of the North Atlantic Ocean for the current month contains some further interesting particulars respecting the track of the destructive West India hurricane of August 3–September 12. After leaving the American coast it at first moved eastward with increased velocity. During the week of August 24–30 it remained almost stationary in the mid-Atlantic, the centre of the disturbance shifting to the northward, from where it took an almost due easterly course to about longitude 20°, traversing the Azores on September 3; it then curved to the N.E. until it reached the vicinity of Brest on September 7, when it bent in a S.E. direction and reached the north of

Corsica on September 9. Whole gales were frequently encountered throughout the course of the storm across the Atlantic. Off the coast of Provence it caused strong N.W. gales and a rough sea on September 9–11. This hurricane can be traced over the North Atlantic for a period of thirty-six days, making it in length of life the most noteworthy storm ever reported to the Hydrographic Office in Washington.

A summary of divers and sundry views respecting the cause of formation of hail is given by Signor Pio Bettoni in the *Bolletino mensuale* of the Italian Meteorological Society. The great divergence of opinion on the subject seems to suggest that we have not made much advance towards arriving at a definite explanation of the phenomenon during the century which has elapsed since Volta published his well-known electrostatic theory. Of the views here enumerated some are modifications of Volta's theory, and attribute the formation of hail to electrostatic causes, others ascribe the phenomenon to whirlwinds (vortices), others, again, to refrigerating air currents, and even the more unconventional theories, according to which hailstones come to the earth from interplanetary space or their refrigeration is due to transmutation of caloric into electricity, are not without their advocates.

In *Himmel und Erde* for September, Dr. E. Less, of the Berlin Meteorological Office, gives a very lucid account of the general circulation of the atmosphere. In the first half of this century our knowledge of weather changes was almost exclusively confined to climatological investigations, in which Prof. Dove, of Berlin, was the most prominent representative; he referred the origin of all winds to an interchange of the air between the equator and the poles. But the study of synoptic weather charts, from about the year 1860, showed that the explanation hitherto given of weather changes did not generally accord with observed facts, and that they were intimately connected with the existence of areas of high or low barometrical conditions. The author points out that while the behaviour of the great atmospherical currents is, generally speaking, capable of explanation, the relation between them and the smaller disturbances which occur in our latitudes leave many doubtful points to be cleared up. In fact, what part is played by the general and what by the local conditions in producing the different phases of weather is as yet but little understood. The explanation of these phenomena is one of the most important problems of meteorological research, the solution of which must be approached in various ways.

The *Bulletin International* of the Cracow Academy contains a notice of a paper, by M. P. Rudski, on the theory of the physics of the earth. In it the author gives a mathematical investigation of the variation of latitude in an elastic spheroid covered with water, and investigates the earth's rigidity as deduced from the 430-day period of the variation. The values deduced depend on the assumed "effective density" of the earth. Taking for this density the values 2·2, 3·0, 4·0, 4·5 and 5·5, Rudski finds the corresponding values of the rigidity to be 567, 879, 1713, 2036 and 2681 times $10^9$ C.G.S. units respectively, that of steel being $819 \times 10^9$. By neglecting the effects of the ocean, and taking for the effective density the value 5·5, the author finds $n = 1250 \times 10^9$.

With a view of contributing data towards the determination of the secular variations of the earth's magnetism, Dr. Emilio Oddone contributes to the *Rendiconti del R. Istituto Lombardo*, xxxii. 15, his determinations of the magnetic elements at Pavia for June 1898, which admit of comparison with the corresponding elements determined by him at the same spot about fifteen years ago. The present results are as follows: declination, 11° 48′ ± 2′; inclination, 61° 26′ ± 2′; intensity in C.G.S. units, horizontal, $0{\cdot}216_3 \pm 0{\cdot}001$; vertical, $0{\cdot}397_3$; total, $0{\cdot}452_4$. While the interval between the present and the previous determination is too short to allow of these observations being made the basis of a new determination of the secular variations of the earth's magnetism, the author remarks that the empiric formulæ for the inclination and horizontal intensity, when exterpolated for fifteen years, agree fairly well with the above-mentioned numbers, but the annual variation in late years comes out to be less than was to be inferred from past observations.

Profs. Elster and Geitel, writing in *Wiedemann's Annalen*, 69, discuss the source of energy in Becquerel rays, and advance the theory that the rays may be due to changes of the molecular arrangement of the atoms of the radio-active substance in which these pass from an unstable to a stable configuration with expenditure of energy. In a second note, the same authors show that Becquerel rays experience no deviation from a magnetic field, but that such a field in certain circumstances decreases the electro-dispersive power of air that has been traversed by them.

In a communication to *Wiedemann's Annalen*, 67, Herr K. Kahle describes at some length experiments with the silver voltameter and their applications to determine the electromotive force of normal elements. The object of the paper is to obtain the electromotive force of the Clark cell, previously determined by the author by means of Helmholtz's electro-dynamometer, independently from the electro-chemical equivalent of silver. The value now obtained for the ratio of the Clark at 15° to the cadmium at 20° is 1·40663. Herr Kahle infers the following results as correct to 2 in 10,000, viz. Clark, 15°: $1{\cdot}4328_5$; cadmium, 20°: $1{\cdot}0186_3$; and Clark, 0°: 1·4492 internal volts.

Dr. Franz Kerntler has published a paper on the unity of the absolute system of units in relation to electric and magnetic measurements, in which he proposes to supersede the present dual systems of electrostatic and electromagnetic units. According to Dr. Kerntler's system, quantity of electricity and quantity of magnetism are both measured by Coulomb's law in C.G.S. units, and are thus both of the same dimensions, being identical with the electrostatic and magnetic units respectively; but a current has two measures, which Dr. Kerntler designates as its "opulence" and its "fecundity." These, which represent its electromagnetic and electrostatic measurements in common parlance, are in the ratio of 1 to "$v$."

Dr. F. J. Allen has contributed to the *Proceedings* of the Birmingham Natural History and Philosophical Society, xi. 1, an essay on the nature and origin of life. The author remarks that the most prominent and perhaps most fundamental phenomenon of life is what may be described as the energy traffic or the function of trading in energy. After briefly pointing out the differences between anabolism and catabolism, Dr. Allen advances the opinion that it is nitrogen which, in virtue of its variability, instability, and lability, plays the most important part in the phenomena of life, and he enunciates the law that every vital action involves the passage of oxygen either to or from nitrogen. In the section dealing with the origin of life, it is stated that life in its physical aspect is the culmination of that chemical instability in certain elements which has always kept them circulating at the earth's surface. Dr. Allen considers that existing conditions are favourable to the origination of primitive forms of vital processes at the present time, and the reason that such forms do not originate now is that the elements required for their development are seized and assimilated by the already developed organisms. In regard to the possible existence of life in other parts of the universe, the same conditions of instability which are peculiar to the group of elements

nitrogen, oxygen, carbon, and hydrogen at ordinary temperatures on our earth's surface may exist in other groups of elements at widely different temperatures, giving rise in parts of the universe, even of the most diverse characters, to developments of life whose variety and magnificence are beyond the utmost reach of our imagination.

A PAPER, entitled "Wanted, Plant Doctors," is to be found in the current issue of the *Contemporary Review*, in which the importance of the subject of plant pathology is briefly dealt with. While giving credit to the workers at the British Museum, Kew, &c., for the attention they are paying to this branch of science, the writer of the paper shows how far behind America and Germany this country is in recognising the importance of the subject. He thinks, however, that this will not be always so; "a time must come when every agricultural district will have its plant doctor, and when specialists in animal parasites, cryptogamic botany, and bacteriology will be consulted in difficult and obscure cases, just as the help of Harley Street is called in by medical practitioners. The practice of plant medicine is in its infancy; but with increased competition in the growth of cultivated crops, the farmer cannot afford to neglect any help that he can get in keeping the plants under his care in as high a state of health as possible." "What better use," adds the writer, "can be found for a philanthropist's money than the founding of a school of practical plant pathology, for the investigation of the diseases which occur in Britain?"

IN the October number of the *Zoologist* the editor, Mr. W. L. Distant, continues his communication on mimicry. While referring only to a limited number of examples, he divides his subject primarily into demonstrated, suggested and disputed cases of mimicry; adding a section on purposeless mimicry, and a second devoted to active mimicry. Under the heading of suggested mimicry the curious resemblances between certain tree-shrews and squirrels, as well as that between the Cape hunting-dog and the spotted hyæna, are rightly included; but it seems a little curious to find the East African Guereza monkey, whose coat has been shown by Dr. J. W. Gregory to present such a remarkable resemblance to the pendent lichens of the trees on which the animal lives, included in the same category. Under the heading of purposeless mimicry are included cases like the resemblance of the bee-orchis to the insect from which it takes its name; while active mimicry denotes those instances where insects or other creatures take special measures to avail themselves of their resemblance to other objects.

THE same journal likewise contains a very suggestive paper by Mr. C. Oldham on the mode in which bats secure their insect prey. It has been observed that these animals, when walking, carry the tail curved downwards and forwards, so that the membrane connecting this organ with the hind legs forms a kind of pouch or bag. If a large insect be encountered the bat seizes it with a snatch, and slightly spreading its folded wings and pressing them on the ground in order to steady itself, brings its feet forwards so as to increase the capacity of the tail-pouch, into which, by bending its neck and thrusting its head beneath the body, it pushes the insect. Although the latter, especially if large, will often struggle violently, when once in the pouch from which it is subsequently extracted and devoured t but rarely escapes. It is assumed that the sme method of capture is employed when on the wing; and a correspondent of the author, who has observed the long-eared bat picking moths off sallows, states that "the bat always hovers when taking off the moth, and bends up the tail so as to form a receptacle for the insect as it drops."

MR. G. C. WHIPPLE and Mr. D. D. Jackson reprint, from the *Journal* of the New England Water-works Association, a paper on *Asterionella formosa*, a diatom which sometimes appears in great quantities in reservoirs of drinking water, imparting to it a geranium-like or fishy odour, from the production of a substance analogous to the essential oils. Its development is seasonal, appearing chiefly in spring and autumn. Its growth is greatly favoured by strong light; and the most efficacious preventative appears to be the storage of the water in the dark.

THE Director of the Botanical Garden at Buitenzorg, Java, has issued the first number of a *Bulletin* of the Botanical Institute, containing a history of the Institute down to the present time, a plan of the buildings and of the gardens, with a list of the plants grown in them, and a list of the official publications. Besides the special laboratory for workers from other countries, the Institute contains laboratories for agricultural chemistry, for phyto-pathology, for agricultural zoology, for pharmacology, and for the study of the coffee and tobacco plants.

PROF. DAVID G. FAIRCHILD gives, in the *Botanical Gazette* for September, an interesting account of a visit to Payta, in Peru, reputed to be the driest spot on the face of the globe. Payta is situated about 5° S. of the equator on a coast which has risen 40 feet within historic times. The average interval between two showers is seven years; when Mr. Barbour Lathrop and Prof. Fairchild visited it in February, there had recently been rain lasting from 10 p.m. one day till noon the next day, the first for eight years. There are frequent sea-fogs. The flora consists of about nine species; of these seven are annuals, the seeds of which must have remained dormant in the ground for eight years. Notwithstanding the scarcity of rain, the natives subsist by the growth of the long-rooted Peruvian cotton, which is able to maintain itself without rain for seven years in the dried-up river-bed, and yields profitable crops of the coloured short staple cotton, which is used as an adulterant for wool.

THE Calendar, for the session 1899-1900, of the University College of North Wales has just been issued by J. E. Cornish, Manchester; and the University Correspondence College Press has published its London University Guide for the same period.

THE *Bulletin of Miscellaneous Information* (Botanical Department) for Trinidad, No. 20, July 1899) contains a report, by Mr. G. Massee, on the cacao pod disease, in which he states that, in addition to the well-known *Phytophthora omnivora*, a second parasitic fungus, *Nectria Bainii*, sp. n., occurs on the diseased pods.

WE have received from the Purdue University Agricultural Experiment Station at Lafayette, Indiana, a parcel of reports (*Bulletins* Nos. 71-79) on various subjects o' practical importance to agriculturists:—The San José and other scale insects; field experiments with wheat; skim milk as food for young growing chicken, &c.

PROF. ELMER GATES describes in the *Scientific American* a number of pictures he has obtained of the electric discharge, by placing a photographic plate between the two poles of a ten-plate electrostatic machine. The illustrations accompanying the article are of much the same character as those given by Lord Armstrong in his elaborate work on "Electric Movement in Air and Water," but they are on a smaller scale, and therefore less full of detail.

A NEW edition—the fourth—of "Our Secret Friends and Foes," by Prof Percy Frankland, F.R.S., has been published by the S.P.C.K. The author has re-written the chapter which was added to the immediately preceding edition, and has added some of the latest results achieved in the study of bacterial

poisons, such as that of bubonic plague, and of some other poisons of a non-bacterial origin.

MESSRS. LONGMANS AND CO. have issued a new edition of Prof. Lloyd Morgan's "Animal Biology." The book was originally published twelve years ago to meet the requirements of the Intermediate Science and Preliminary Scientific Examinations of the London University. The present edition has been revised, and some chapters re-written, to meet the requirements of the existing syllabus. Several illustrations now appear in the work for the first time.

NEW editions of two well-known books of chemistry (Ostwald's "Grundriss der Allgemeinen Chemie," and Lothar Meyer's "Outlines of Theoretical Chemistry," the latter translated by Profs. Bedson and Williams) have recently come to us from their publishers—Engelmann of Leipzig, and Longmans and Co The former is a third edition, and the latter a second, and an attempt has been made in each case to bring the work up to date.

REFERENCES to practically every article and work on geography published during the year 1896 will be found in the fifth volume of the "Bibliotheca Geographica," prepared by Dr. Otto Baschin for the Berlin Geographical Society, and just published by the firm of W. H. Kühl. A comprehensive classification of subjects is adopted, and it is easy to find the works published in any branch of geography in 1896. In adtion, there is a complete index of authors. Students of geography know the work so well that no comment upon its thoroughness is necessary here.

THE additions to the Zoological Society's Gardens during the past week include a Green Monkey (*Cercopithecus callitrichus*) from West Africa, presented by Mr. G. P. Kinahan; a Macaque Monkey (*Macacus cynomolgus*) from India, presented by Mr. A. M Burgess; a Gambian Pouched Rat (*Cricetomys gambianus*), a Nilotic Trionyx (*Trionyx truinguis*) from Sierra Leone, presented by Mr. Ernest E. Austen; a Red-footed Ground Squirrel (*Xerus erythropus*) from West Africa, presented by Mr. F. H. D. Negus; two Herring Gulls (*Larus argentatus*), British, presented by Mr. J. W. Edgar; a Melodious Jay Thrush (*Leucodioptron canorum*) from China, presented by Mrs. Currey; a Spoonbill (*Platalea leucorodia*), a Kestrel (*Tinnunculus alaudarius*), captured at sea, presented by Captain E. W. Burnett; a Green Turtle (*Chelone viridis*) from Ascension, presented by Mr. W. Hebden, C.E.; a Chameleon (*Chamaeleon vulgaris*) from North Africa, presented by Mr. F. G. Ward; two Serrated Terrapins (*Chrysemys scripta*) from North America, a Bennett's Cassowary (*Casuarius bennetti*) from New Britain, a White Goshawk (*Astur novae-hollandiae*), two Sacred Kingfishers (*Halcyon sancta*) from Australia, a Forsten's Lorikeet (*Trichoglossus forsteni*) from the Island of Sambawa, a Ring Ouzel (*Turdus torquatus*), British, deposited; a Crabeating Raccoon (*Procyon cancrivorus*), two Short-eared Owls (*Asio brachyotus*) from South America, purchased.

## OUR ASTRONOMICAL COLUMN.

HOLMES' COMET (1899 *d*).

*Ephemeris for 12h. Greenwich Mean Time.*

| 1899. | R.A. h. m. s. | Decl. ° ′ ″ |
|---|---|---|
| Oct. 26 | 2 45 7·14 | +49 11 29·7 |
| 27 | 43 55·55 | 13 2·6 |
| 28 | 42 43·32 | 14 12·0 |
| 29 | 41 30·56 | 14 58·0 |
| 30 | 40 17·40 | 15 20·5 |
| 31 | 39 3·95 | 15 19·6 |
| Nov. 1 | 37 50·33 | 14 55·4 |
| 2 | 2 36 36·67 | +49 14 8·0 |

NOVA SAGITTARII.—*Harvard College Observatory Circular*, No. 46, gives the details of the position of Nova Sagittarii, discovered in April 1898, as obtained from micrometric measurement of enlargements from the plates, taken with the 8-inch Bache and 11-inch Draper telescopes, on which the star was photographed. Prof. Pickering finds that the accuracy obtainable by this method is equal to that given by the best meridian circle observations. The mean position as determined is

$$\left.\begin{array}{l}\text{R.A.} = 18\text{h. } 56\text{m. } 12{\cdot}83\text{s.}\\ \text{Decl.} = -\ 13^{\circ}\ 18'\ 12''{\cdot}98\end{array}\right\}(1900).$$

ORBIT OF EROS.—In the *Astronomische Nachrichten* (Bd. 150, No. 3597), Herr Hans Osten, of Bremen, discusses the numerous observations of the new minor planet now available, and gives the two following provisional sets of elements for the orbit:—

*Epoch of Nodal Passage*, 1898 *Oct.* 1·0. *Berlin Mean Time.*

| | I. | II. |
|---|---|---|
| | ° ′ ″ | ° ′ ″ |
| $M =$ | 238 38 33·627 | 238 39 44·636 |
| $\omega =$ | 137 9 24·77 | 177 39 21·05 |
| $\Omega =$ | 342 8 48·58 | 303 31 53·37 |
| $i =$ | 30 42 32·105 | 10 49 33·99 |
| $\phi =$ | 12 52 17·14 | 12 52 18·33 |
| $\mu =$ | 2015″·57814 | 2015″·34326 |
| $\log a =$ | 0·1637380 | |

STRASSBURG OBSERVATORY.—The annual publication compiled under the supervision of Herr E. Becker, the director of the Imperial Observatory of the University of Strassburg, has recently been issued, containing the reductions of star observations made during the period 1882–1888, together with miscellaneous results to 1893. The observations made with the meridian circle, occupying 154 pages, are preceded by some twenty pages giving details of the determination of collimation, level, azimuth and other corrections. Following these are given the individual observations of the positions of 223 stars measured from 1882–1883, and of 1146 stars measured during the period 1884–1888. From these three catalogues are compiled, one of 254, one of 858, and one of 368 stars, the latter containing corrections from Epoch 1880. Three appendices deal with heliometer measures of the partial solar eclipses of 1890, 1891 and 1893, the determination of the form the pivots of the meridian circle of the observatory, and the compilation of precession tables (both annual and secular) respectively.

## THE NERVE-WAVE (LA VIBRATION NERVEUSE).[1]

AS you told us, sir, two days ago in your admirable address, the century now drawing to an end is most honoured in the close union of men of science of all nations. If, owing to stupid prejudices and barbaric hate, nations are still separated by divisions which may lead them into fratricidal war, it falls to the men of science at least to set the example of concord, in order that by their teaching, based on reason, they may bring to all peace, sweet peace—the chimæra of the past, the hope of us all to-day, the reality of to-morrow. To this end nothing can be more effective than the great example of the British Association and the Association Française, who, within the space of a few days, are to meet twice as partners in their fertile work: to-morrow on English soil, in this hospitable town of Dover; five days later on the soil of France, on the shores you can see from here, where you will find the same courteous and cordial welcome as our countrymen will receive on this side.

Yet after these words of peace must come words of war—nay, its open declaration. Men of science have not the right to stay within the closed gates of their tower of ivory; it behoves them also, even at the cost of vain popularity, to wrestle and to wrestle unceasingly for justice; to form a grand international league, to turn the united forces of all generous minds against the common foe, the worst enemy of man: and this is ignorance. We must not value unduly the admirable conquests won by science in this century. Admirable as they are, they are yet nothing as compared to the great mystery beyond. Newton compared our science to that of a child, who should pick up a pebble on the

[1] Evening Address delivered by Prof. Charles Richet on September 15, at the Dover Meeting of the British Association. Translated by Prof. Marcus Hartog.

sea shore, and think he has penetrated the secrets of ocean. After all our searchings and all our efforts, to-day we can hardly say more. The shades that surround us are as deep as in the time of Newton; and in this universe, vast and obscure, at most scattered glimmers of light, few and far between, reach our straining eyes.

We need all the co-operation of all men of science, of all nations, to dispel some of these shades. What madness it would be not to unite, not to walk hand in hand, but to strive apart! The reward of this union will be above all price: the conquest of truth, the control of brute matter, the gift of a life less precarious and less painful to man, feeble man.

And so you see what we should think of those self-styled patriots and nationalists, who speak of French science, English science, German science, as if science were not international, and lifted high above our vain frontier limits.

To the history of nerve-waves many workers of diverse countries have contributed their share; as with every great scientific problem, every country of the world has taken part in its solution. But before I go on, let me pray your indulgence for treating of so arid and so difficult a subject before you.

I.

The world around us presents itself in different aspects to the eyes of the student and of the layman. The layman sees external objects, endowed with properties apparently inherent in them, and commonly defined by the impressions made on our senses. A given object is warm, light, electrified, heavy, and so forth; and every one thinks that heat, light, electricity, weight, are so many realities, distinct from the object itself. But the man of science conceives matters otherwise. For him this vast universe is formed of an indefinite "something" termed "Energy," and he knows that this force may have different manifestations in motions of diverse kinds. We are almost justified in saying that "Energy is one"; that its aspects appear to our senses so different because the various movements of this energy have not all the same qualities. They differ in number, in frequency, in rapidity, in form; and according to these different modalities which we perceive, and to their results, we have heat, light, electricity, attraction.

The movements of this energy are all transmitted in the same way, by wave-motion—"undulation" or "vibration," as we call it; and the physicists, by wonderful research, in which the highest mathematics must be utilised, have succeeded in determining the forms of certain kinds of these waves. And even those motions of energy which we do not so well understand, we are justified, by what we do know, in regarding also as wave-motions or undulations.

I need not dwell on this phenomenon of undulation or vibration. We all know the simple case when a pebble is dropped into still water: and the surface, which was smooth as a mirror, now shows a series of disturbances propagated in ever-widening concentric circles. In each oscillation we see two periods: in the one the water recedes from the primitive plane of the mirror, in the other it comes back to it again. The former is the *period* of *departure*, the latter that of *return*.

So, if we hit a hanging weight, a pendulum, the shock at once removes it from its position of equilibrium, and it recedes further from it (period of departure); then it comes back again to its starting point (period of return). What I have called undulation and vibration are two names for the same phenomenon, of the greatest diversity in form, but essentually due to the wave-motion of a fluid. Though, if you will, this fluid, the ether, be of very hypothetical character, we will take it for granted here, and say that heat, light, electricity, gravitation, are all wave-motions of the ether.

Consequently, the outer world in its infinite diversity of aspect, in form and in colour, is the sum total of the various vibrations of force. These vibrations, most diverse in character and in intensity, act upon the living organism, and produce sensations therein. Now it is probable that, as I shall try to show you directly, these vibrations of the outer world only act on our senses by evoking within us another kind of vibration, to which are due sensation and perception. Thus the nerve-wave is revealed to us as the goal and the final term of the vibrations of the external world. Were there no nerve-wave, though, no doubt, all these external vibrations would still exist, still they could produce no effect on us. In virtue of its own proper vibrations, the living being becomes the microcosm, the recipient of the diverse vibrations of the macrocosm, the universe: by these vibrations only is the universe accessible to our understanding. Thus you see what of interest lies in the study of this nervous vibration, since through it the outer world is known to us, and through it we have the power to act on the outer world.

II.

This study is no new one; I should trespass beyond the limits of your courteous attention were I to try and recount all the classical facts that are well known at present. Yet, that you may understand the new facts I am coming to presently, I shall have to give you a short summary of some of these classical facts; and I hope that despite their being so well known, they will not be devoid of interest to you.

The nervous system is made up of distinct elements, each consisting of a cell, with very long fibrous outgrowths. These cells with part of their outgrowths are compacted into the central nervous system, while the rest of the outgrowths are produced into strands, the peripheral nerves. An elaborate microscopical analysis of the last few years, largely due to Golgi and to Ramon y Cajal, have shown that the total number of processes is countless. Each cell sends forth at least one outgrowth, the *axis cylinder*, which remains unbranched except at its very termination; while the others, like the branching roots of a forest tree, spread out in all directions, so that they interlace with those of its neighbours. Thus all the nerve-cells are in communication; the disturbance of one may affect all. And this disturbance may be propagated far and wide; for in the peripheral nerves pass out the axis-cylinders, which separate ultimately and get up to the very tips of the limbs, to the skin, the entrails, the muscles, and the glands. Think of the whole surface of the skin as provided with little nerve apparatuses, all capable of vibration and of transmitting their undulations through the sensory nerve-fibres to the nerve-centres; of the nerve-centres as possessing processes like the sensory fibres, whereby to transmit their orders to the muscular and glandular organs; and you will be able to realise the part played by the nerves in the life of the organism. It is a vast telegraphic apparatus, to receive, by its sensory receptive mechanism, all impressions from without, and to transmit, by its transmitting mechanism, corresponding messages to the organs of motion, the muscles. And, since all the nerve-cells are, moreover, in communication with one another, and since every living cell is in relation with nerves, we may sum up the relations of the living organism in this general formula: through the nervous system, any one living cell reverberates in every other cell, and is reverberated to by every other cell. Thus the living organism that possesses a nervous system is no mere aggregate of cells; it is an *individual*, all the parts of which co-operate for the common weal.

The nerve-cell, together with its prolongations, has received the name of "neuron"; we can conceive that by the interrelations of all its neurons the living organism may be regarded as one gigantic neuron, sensible to all stimulations at the periphery, and answering them by stimulations of the motor apparatus, which are translated into acts of motion or of secretion. This sensibility and its motor response are linked by a phenomenon which we shall call for the present the "nerve-vibration" or "nerve-wave." How far is this name justified? This is the question that we have to deal with.

III.

Let us for the moment make the assumption (which is not quite exact) that the phenomena are identical in the peripheral nerves and in the central nervous centre, and that what applies to the one will also apply to the other.

We may, at least, accept them as analogous, since the axis-cylinder of the peripheral nerve is an expansion of the protoplasm of the nerve-cell. True, the reactions of the peripheral and of the central nerve tissue are not identical; but their differences are probably in accessories, not in essentials. We may, therefore, boldly accept their analogy, if not their identity; and we are justified in applying to the one the truth that we learn of the other.

The pace at which an impulse travels along a nerve is well known since 1850. Strange to say, just two years before, a great physiologist, one to whom the science is indebted for some of its grandest advances, Johannes Muller, declared that it was impossible for us to determine the speed of nervous transmission—an affirmation as imprudent as are all affirmations which proscribe formal conclusions to the science of the future.

Well, as I say, just two years after this unfortunate prophecy of Johannes Muller, Helmholtz ascertained that, if you determine the time of response by stimulating a nerve at a given point, you can determine the rate of transmission by stimulating the same nerve at a measured distance, say a decimetre, above that point; for, as in this case, the response will be delayed, the period of delay measures the rate the nerve impulse has taken to travel over ten centimetres. Since then countless determinations have been made of the speed of the nerve-current. It has been found to vary with the temperature and with the character of the nerve stimulated; it is less rapid in the nerve-centres than in the peripheral nerves, less in cold-blooded than in homœothermic (or so-called warm-blooded) animals. But it never differs much from thirty metres per second.

Moreover, this nerve current has been found to be always transmitted in both directions from the point of stimulation. I will not dwell on the exceedingly technical proof of this law, but merely recall the fact that whether the nerve stimulated be motor or sensory, the nerve current travels both ways along it, both towards the periphery (skin, muscle, &c., as the case may be) and towards the central nervous system.

A most important fact is that an electrical disturbance accompanies every stimulation of a nerve. If in the undisturbed condition we place the poles of a circuit with an interposed galvanometer at two points of a nerve (one on its surface, the other on a cut end), to ascertain its electric condition, we find that there is an electric tension between them, that there exists in the nerve a certain current. If we then stimulate the nerve, the current is seen to be reversed, or, as we say, undergoes a "negative variation," and the rate at which this change is transmitted is sensibly the same as that of the nerve-wave. Matteucci, Du Bois Reymond, Bernstein, Waller have studied all the complex details of this process; so that it now ranks among the best known phenomena in physiology.

We ask:—Are there, concurrent with this electric variation, modifications in the chemical and thermic condition of the nerve or nerve-centre? Yes, in all probability; but the answer is not certain. Schiff thought that by stimulating the retina of the pigeon he induced a change in the temperature of the brain. Mosso also thought he could find localised areas of higher temperature in the brain after stimulating certain points; but the elevation of temperature is, to say the least, of low intensity and difficult to determine.

In this rapid sketch, the last law I have to formulate is *the law of the integrity of the organ*. The physical and mechanical union may be maintained; but if its organic continuity be severed as by a cut, even when the two ends are joined up, the nerve-current is no longer transmitted.

IV.

Several hypotheses may be put forth as to the nature of this phenomenon.

Formerly, when words were accepted in place of facts, it was said that there was a transference of "animal spirits" (a conception due to Descartes); this was the current expression in the sixteenth, seventeenth and eighteenth centuries. A curious apparent confirmation was found in Richard Lower's experiment: he tied a nerve, and saw that it swelled above the seat of ligature; this, said he, was the accumulation of the animal spirit, arrested by the tightened thread. The experiment was a perfectly valid one; and you see that from it it was possible to deduce conclusions that were perfectly false. The swelling was due to the increase of blood pressure and to inflammation.

We may drop this old hypothesis of "animal spirits," and pass to four theories put forward to explain the nature of the nerve-current.

(1) *Mechanical Hypothesis.*—If, as is probable, the semi-fluid protoplasm of the nerve-cell and its prolongations form one continuous whole, it follows that a mechanical disturbance of this liquid mass will be propagated to a distance along the whole length. Suppose a capillary tube filled with mercury; a disturbance of the mercury will be propagated the length of the tube, so that at the far end we perceive a vibration started from the opposite end. In this case the nerve-wave would be the molecular disturbance of a liquid enclosed in a capillary tube.

This hypothesis would afford a fair explanation of the electrical phenomena involved; for we know that the friction of a fluid in a capillary tube produces electricity. However, this mechanical explanation presents certain difficulties, for in a capillary tube the narrower its calibre the more rapidly the vibration is damped; consequently, it is hard to conceive that a vibration could be transmitted so as to be appreciable at the far end of a tube one or two metres long. It is true that we can form no supposition as to the absolute measurement of such perturbation; and perhaps almost infinitesimally small forces are adequate.

On the other hand, the electric disturbance that accompanies the nerve-wave does not lose intensity as it travels: on the contrary, Pflüger and other physiologists declare that it grows like an avalanche. Hence, taking all considerations into account, the nerve-wave is a phenomenon other than a mechanical vibratory molecular disturbance of the semi-fluid protoplasm.

(2) *Chemical Hypothesis.*—The transmission of the nerve-wave along a nerve has been compared to the explosion of a train of powder, or of mixed gases in a tube; and this you know is transmitted relatively slowly, nay, very slowly if the tube be of capillary dimensions. If, say, an explosive mixture of oxygen and hydrogen be contained in a very narrow tube, and a flame or spark applied at one end, the combustion will not be instantaneous, but will pass as a wave along the tube, and that a very slow wave, if the tube be narrow.

What at first sight would give some plausibility to this hypothesis is the fact that a very feeble stimulus may call forth a very strong response. Take the amount of energy received by a surface of 1 sq. cm. from a candle 300 metres distant; it is 1/10,000 millions of the total light-giving energy of the candle, a quantity whose absolute value is in one sense a negligible quantity, but which is adequate to give a sensory stimulus to the retina. The retina must be supposed to contain a quantity of accumulated energy susceptible of explosive liberation, so that the amount freed would be far in excess of the energy of the stimulus.

But there is one very serious objection to this hypothesis; it demands that the explosive tissue should be reconstituted afresh immediately after each explosion. It is not easy to see how the moment after the explosion, in the hundredth of a second, the nervous substance could be reconstituted afresh. Though serious, the objection is not irrefutable, for we know too little of the speed or slowness of the chemical changes of the organism to use this as an argument against any theory whatever.

(3) *Electrolytic Hypothesis.*—Certain chemical changes are characterised by their allowing of an immediate reconstruction after their occurrence, such are the phenomena of electrolysis. When a current passes through a saline solution, it is believed that, as it passes along, the salt is decomposed from place to place, and immediately reconstituted as soon as the current has passed. The passage of the electrolytic current is sometimes exceedingly slow. There is nothing to prevent our accepting some such explanation of the nerve-wave; it has the advantage that it can be brought more or less into harmony with the chemical and the electrical hypothesis, and can indeed reconcile them.

(4) *Electric Hypothesis.*—This supposes that an electrical current passes along a peculiar form of conductor—the nerve. The chief objection that has been urged, in the extreme slowness of the nerve-wave—30 metres per second—as against 700 million metres, the alleged rate of electricity. But this omits to take account of the fact that electricity travels at this speed in good conductors only. Electricity passes along a conducting wire, ten thousand, a hundred thousand, times as fast as along a badly conducting tube; it is only reasonable to admit that the transport of electricity may be enormously retarded in a capillary tube filled with a very bad conductor. It has also been urged that, since different nerves can transmit very different sensations simultaneously to the different parts of the nervous system, there should be a blurring and confusion from the imperfect insulation of the tubes if it were electricity that they conducted.

"How, for instance," we are asked, "could nerve-cells of the cord and the brain communicate their electrical disturbances in narrowly localised groups with that extraordinary precision, without the neighbouring cells feeling the effect?"

We do not attach much weight to this objection because, in the first place, the axis cylinders have an insulating covering of myeline, as have also the cells of the brain; and again, in electric fishes, electric shocks one hundred thousand-fold as strong pass between certain organs without the rest being at all affected, so perfect is the insulation.

Thus the hypothesis that the nerve-wave is an electric phenomenon is fairly satisfactory, especially if we admit that it resembles electrolytic action.

Certainly we must allow for the unforeseen ; we must recognise the possibility that, perchance at no very distant date, we may receive the formal demonstration of fundamental differences between electrical and nervous vibrations, and have to admit that the latter possess special characters which differentiate them from all known classes of vibrations.

V.

I now come to a different order of facts, on which I will speak more fully, for I have to deal with my own researches, some, indeed, as yet unpublished. These I carried on in collaboration with M. André Broca ; they are, I think, of a character likely to shed light on some of the conditions of the nerve-wave. True, they tell us nothing of the actual nature of nerve-vibration ; but they will allow us to deduce the form of the nerve-wave.

Our experiments were made on the nerve-centres, not on the peripheral nerves ; as a matter of fact, we believe that the laws which we have discovered for the one will apply to the other, and Charpentier's recent and most ingenious researches confirm this assimilation.

We must go back to the very definition of a vibration. We have seen that it is a movement of oscillation, an object is removed from a position of equilibrium and comes back to it again. Such is a *simple oscillation ;* in a *complete wave*, after returning to the position of equilibrium from the furthest point, it passes that position and only returns after a certain traverse in the opposite direction.

If we call the first simple oscillation from the position of equilibrium the *positive phase*, the second oscillation is regarded as the *negative phase* of the complete wave. Now the phenomenon is no simple one ; the return to equilibrium is not

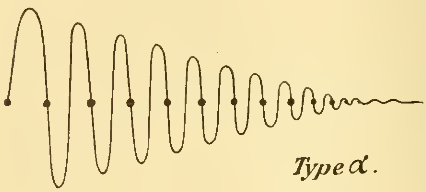



FIG. 1.

durable, and if no new condition intervene the vibration will continue. Were there no friction or resistance the vibration would persist indefinitely ; for there is no reason for the motion to stop, and the pendulum, to take the very simplest case, would never return to rest at its original position of stable equilibrium. To stop the vibration there must be some deadening or *damping* process.

Physicists have studied the modes of damping, and find that they are divided into three types.

Type $\alpha$ is that of a pendulum, a vibrating string, or the waves of liquid when a stone enters the water. A series of complete waves follow with smaller and smaller oscillations, and the vibration dies out by the gradual decrease of the waves—secondary, tertiary, &c.—which followed the primary wave. This type of damping is, as we have said, due to the resistance of the medium consuming part of the energy ; for, theoretically, a vibration once started would never stop. You are familiar with the fact that a pendulum continues to swing much longer in vacuo than in the air, and I need not dwell further on this point (Fig. 1).

Type $\beta$ shows a very different character in its damping. After the pendulum has completed its first phase and passed the point of equilibrium, it meets a certain obstacle to its return point ; it only swings back again very slowly thereto, and on reaching it it cannot pass beyond it. Indeed, from diverse theoretical considerations it may be proved that it never returns absolutely to the point of equilibrium ; it approaches it indefinitely without ever reaching it ; in short, ABA′ is an asymptotic curve of which AA′ is the asymptote. Later on we shall see what conclusions may be drawn from this as to the nature of the nerve wave. Suffice it now to demonstrate the form of the wave with this type of damping. Practically, stable equilibrium is reached sooner than by type $\alpha$ : indeed, this is the type of damping used in the transmission of signals by submarine cables ; where it is necessary to prevent each signal from producing a whole series of swings of the galvanometer needle, and to obtain as rapidly as possible its return to equilibrium and rest (Fig. 2).

Type $\gamma$ remains to be described : here the pendulum, after being moved from the point of equilibrium, returns only very slowly to that position ; this it does, for example, when hanging in a very dense medium. In this type of damping, as in $\beta$, there are no consecutive secondary and tertiary vibrations ; nay, more, the damping is here so complete that there is no negative phase, only a simple oscillation. This curve is also asymptotic, and the return never reaches the primitive state of equilibrium (Fig. 3).

We see at once that the form of the wave is determined in each case by the type of its damping, and our experiments have

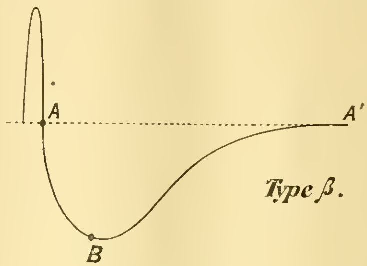



FIG. 2.

enabled us to determine the character of the damping of the nerve-wave. We might have set type $\alpha$ aside *à priori ;* it would have been unreasonable to suppose it. If to wave I succeeded waves 2, 3, 4, &c., a single stimulus would produce a whole series of responses ; now this is not the case with the nerve. Hence the damping must be on the type of $\beta$ or of $\gamma$. But obvious as these considerations are when once stated, we did not reach them *à priori ;* it required actual experience to enlighten us ; so true is it that in science, at least in physiological science, experiment is more fertile than dialectic.

VI.

The following were the methods by which we determined the form of the nerve-wave. I will not describe our research in order of time ; I shall only select some of the simplest, the most demonstrative, experiments. We know that but rarely are the earlier experiments one or the other ; they are complex and

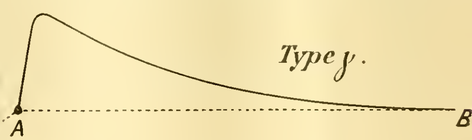



FIG. 3.

slow, and it is only by degrees that one learns how to simplify them and make them direct.

A dog is anæsthetised by the injection of a sufficient dose of chloralose into the veins (0·1 gramme to the kilo. of live weight), and electrodes are applied to the surface of its head. We can now observe the effects of an electric stimulus on the cerebral cortex under excellent conditions. The electrodes can be fixed immovably, so that the same part of the cortex is always stimulated ; and the effects of the stimulus are always localised in the same muscles. If we repeat the same electric stimulus, supplied by a secondary current from accumulators, always of the same suitable intensity, we find that each successive electric shock, repeated at intervals of one second, calls forth a regular and equal muscular contraction in response. This regularity is complete, and if the conditions of circulation and respiration are kept satisfactory for one, two, or even three hours, we have a

series of regular contractions which are easy to register. But when we quicken up the succession of the stimuli, there comes a time when the responsive contractions lose their regularity: a normal contraction is followed by a small one, a large one by a small one, and so on. Thus we can determine at what rate of intermission of the successive stimulations their responses lose their regularity: we find that when the intervals between the induction shocks are less than the tenth of a second, at the normal temperature of the body (39° C. for the dog) the contractions are no longer regular. Matters now go on just as if, after the large normal contraction, there were a *refractory period*, during which the excitability of the nervous system is lowered.

Marey, in his beautiful researches on the heart, had previously showed that after a contraction of the heart there is a short refractory period during which it is not excitable. So, after the stimulation of the brain, a period not exceeding 1/10″ intervenes during which it is not excitable, a refractory period.

Whatever be the temperature of the animal under experiment, we always find this refractory period, which, however, becomes easier to measure when the temperature falls, for then it lengthens out enormously. It is 0·1″ at 39° C.; 0·18″ at 35° C.; and if we chill the dog greatly, to 30° C., it rises to 0·6″. Hence it is advantageous to chill warm-blooded animals for the purpose of these observations.

It is noteworthy that this refractory period can be demonstrated otherwise than by electrical stimuli; mechanical shocks will also serve the purpose. If we poison a dog with chloralose, it becomes extremely sensitive to every mechanical disturbance. The least jolt of the table on which it lies makes it start, and though insensible, and not susceptible to pain, it responds to every jolt by a start. We can register these starts; and if, working with a dog cooled to 30°, we repeat the jars at intervals of less than half a second, the starts lose their regularity. Under these conditions a big start is followed by a small one, and *vice versâ*, though the jolts of the table are quite equal. In successful experiments we may even find the second shock absent; so that if the times of the successive jolts be noted as $a$, $a^1$, $a^2$, $a^3$, $a^4$, &c., we only get responsive shocks at $a$, $a^2$, $a^4$, &c.

The physicists have given the mathematical and mechanical explanation of this phenomenon, which they call the "*synchronisation of the oscillators*"; it has recently formed the subject of an important memoir by Cornu, which, however, I cannot describe even in abstract here. Suffice it to say that these refractory intervals presuppose the existence of a refractory period, of a *negative phase* in the nerve-wave.

The synchronisation of the nervous oscillation with that of the stimulus can only be explained by the assumption of the vibration of an apparatus (the nervous apparatus) possessing a proper period of its own, and with which we regulate and adjust the proper period of a second apparatus (the stimulating apparatus).

Thus, by this method we have succeeded in determining the duration of the nerve-wave; and we may state that this is 1/10″, an exceedingly slow rate as compared with electric or luminous vibrations, whose period is measured in 1-one thousand millionths or billionths of 1″.

We can also determine the form of the wave, and we find it approximate to our type $\beta$. If we consider the period of 0·1″ which elapses between the stimulus and the completion of the nerve-wave, we find that it may be divided into two periods: (A) in the first part a second stimulus will augment the effect; it is the "*phase of summation*" or *positive phase* of the wave. (B) in the second period the stimulus produces a decreased effect; this is the "*phase of subtraction*" or *negative phase*. Now the phase of summation is very small, scarcely more than 0·01″, while the phase of subtraction is very long, nearly 0·09″; but I must not go into more detail on this point, lest I should enter on matters too strictly technical, which I prefer to avoid.

## VII.

In cold-blooded animals the phenomena are quite different; and recent experiments have shown us how imprudent it would have been to generalise too hastily. If, indeed, we repeat the experiment on a tortoise, we find results apparently contradictory of those I have just related to you. A stimulus following another always appears to produce a stronger response than its predecessor. *There is no refractory period, there is a summation phase all the time.* Of course I mean that the stimuli must not be too far apart; if the interval exceeds 2″, two successive stimulations of the brain call forth equal contractions. But with intervals of less than 2″ summation phenomena are always observed, the more marked as the interval between successive stimuli is decreased. Finally, as I say, there is no refractory period.

Hence we may conclude that in cold-blooded animals (at least in the tortoise) the nerve-wave has a different form from that of the dog; after the displacement from the primitive position of equilibrium there is only a slow and gradual return, without any such backward oscillation as explains the negative phase in the dog. This form of wave we have described under the third type of damping (type $\gamma$) (Fig. 3).

This type of wave is exceedingly slow; if the tortoise be chilled by the use of suitable stimuli, we can estimate its duration at 2″. But with normal animals at 15° C. the period may perhaps be taken as 1″.

This difference of tenfold is not surprising; there was no antecedent improbability in conceiving that the nervous phenomena of a tortoise are ten times as slow as those of a dog.

## VIII.

The fact that the nerve-wave lasts one-tenth of a second in the dog, as it probably does approximately in man, opens up a field of interesting considerations which confirm the results of direct experimental physiological observation.

If the nerve-wave lasts 1/10″, it follows that two nerve-waves cannot remain completely dissociated when they follow at shorter intervals than this. Suppose that a stimulus of light calls forth a nervous reaction, a sensation; this reaction, this sensation, will last at least one-tenth of a second; and consequently when a fresh stimulus follows on the first, its sensory response will not be clearly distinct unless this interval at least separates the two. If they follow more closely, they will blend together. Well, a classical and well-known experiment tells us that we cannot receive more than ten or eleven distinct retinal sensations in a second. At eleven per second, we already experience *flickering*; that is, the images are becoming confused. This, the persistence of retinal images, is the familiar principle of the cinematoscope, which has latterly received such elegant popular applications on a large scale.

No such exact studies have been made on the confusion of acoustic or tactile stimuli. But the very remarkable and concordant results of retinal sensation are enough to prove that the cerebral vibration consequent on a stimulation of the retina has a period of 1/10″.

If we turn to the case of a voluntary movement, determined also by a cerebral nerve-wave, we find the same figure. Schäfer in 1886 determined that distinct successive muscular contractions, voluntary or called forth (as reflexes) by electrical stimuli, very rarely exceeded 11–12 per second. Herringham found a frequency of 9–12 in pathological tremors. In the case of shivering from cold, I have determined frequencies of 10, 11, 12, 13 per second. Griffiths determined a frequency of 10 for the muscles of the thumb, and 14 for those of the arm. The Swedish physiologist, Loven, found that the electric oscillations of the cord determined by very frequent stimuli were only 8–10 per second.

Yet we know that if muscles be stimulated directly by rapidly alternating currents, they will contract with much greater frequency. The numerous physiologists who have studied the subject are agreed that we may thus determine as many as thirty or forty muscular contractions per second. If then we can only produce some ten voluntary contractions in the time, the cause lies, not in the muscles, but in the cerebral apparatus, which cannot vibrate more rapidly. Its period is 0·1″; it can only vibrate ten times in a second—can only order ten distinct voluntary movements of the same muscle in a second. It is not that the muscle cannot obey, but that the central nervous system cannot give its orders at a greater speed.

Now I will give you an experiment that you can all try for yourselves, which proves most clearly that the vibration of the nerve-centres determining a psychological phenomenon lasts about one-tenth of a second. When I thought over the various modes of obtaining a very rapid muscular motion, it occurred to me that perhaps the best was the articulation of some sentence pronounced with the greatest possible rapidity. We may admit that every syllable articulated represents a distinct muscular contraction, and consequently a distinct effort of the will. On trying what was the greatest speed of articulation, I found it

was eleven syllables a second; and, indeed, at this speed all the syllables were not perfectly articulated.

This experiment has no particular interest in itself, for it only confirms the results of Schäfer, Lovèn and Griffiths, that repeated voluntary muscular actions have a speed of some ten or twelve per second. But, if we modify it slightly, its bearings are much wider. If instead of *vocally* articulating the syllables, we *think* them and articulate them only *mentally*, we exclude muscular action from any share in the process, and the rapidity of the mental articulation will be the index of the cerebral rhythm, not the muscular. Well, I found, as any of you can do with the help of a good seconds watch, that the mental articulation gives exactly the same figure as the vocal; that is, ten or eleven syllables per second.

We come to the interesting and relatively unforeseen conclusion that the cerebral phenomena of feeling (in the retina), volition (on the muscles), and thought (in mental articulation) cannot be repeated faster than twelve per second, and that they last about one-eleventh, or in round numbers one-tenth, of a second; the isolated sensation, the isolated act of will, the isolated intellectual process, have all the same minimum duration.

Placing this result next to our determination of the period of the nerve-wave, we conclude that there is here more than a mere coincidence; it is an *à posteriori* proof of our hypothesis as to the period of the nerve-wave.

From the psychological point of view this leads us to very important deductions. Of course we can conceive the second to be divided into hundredths, millionths, billionths; but these divisions have no relation to our direct consciousness. Our consciousness can only perceive much longer intervals. Our cerebral organisation determines narrow limits for our appreciation of time. We may therefore define the *psychological unit of time*, the irreducible unit, as *that minimum duration of time which is appreciable to our intelligence*. This is, indeed, susceptible of further theoretical subdivision; but such subdivisions correspond to no real mental image.

We may say, in other words, that the minimum time which our consciousness can directly apprehend is, in round numbers, one-tenth of a second.

"Swift as thought" is an everyday phrase; but you see thought is not very swift, after all, if we compare it to the enormous frequency of the vibrations of light and electricity.

Sir William Crookes, one of your most illustrious presidents, spoke of the relativity of our knowledge in his recent address; he alluded to the cruel imperfections of our animal nature. For us there exists no time-interval shorter than one-tenth of a second; and yet during this short interval, within which our gross intellectual apparatus cannot penetrate, who knows what sequences of phenomena may go on, which we could perceive if our nervous system had a shorter period of vibration? Then would phenomena which we perceive as continuous reveal their true character of discontinuity; those molecular vibrations which to us do not appear as vibrations would take on their real aspects. In a word, our time-unit, which is so different from the units of many phenomena of matter, makes us live in one perpetual illusion.

One more point I wish to touch upon is interesting in many respects. Let us come back to the diagram I gave you above to show the mode of damping of the nerve-wave. I told you that the original level is never regained when the system is damped to a position of rest; it approaches the level indefinitely but never reaches it. Practically speaking, equilibrium is reached at the end of the tenth of a second; physically and physiologically speaking, everything is set in order; the nerve-wave is ended, and the return to equilibrium is total. But if we deal with infinitesimal quantities this return is not complete; so that if we imagine an apparatus capable of appreciating infinitesimal quantities, it would show that, as the mathematical theory predicts, the return to equilibrium is never complete or absolute.

Well! we may fairly suppose that consciousness is alive to this infinitely small quantity, and that the impossibility of the complete return to the primitive equilibrium accounts for the strange phenomenon, unknown in the inorganic world, which we call *Memory*.

After a nerve-wave, the neuron is no longer in the same state as before; it retains the memory of the wave, and this makes it now other than what it was. I pronounce the vowel "A"; one-tenth of a second later I can pronounce some other vowel, for my nervous system has returned to equilibrium; but this return, however, is not complete, for the memory of the "A" which I pronounced persists, and will persist indefinitely. The primitive condition will never recur, whatever happens. In time the memory of the vowel "A" will gradually fade, but it will never be effaced. A nerve-wave of the brain is never completely extinguished.

The fact is that we are here on the confines of two totally distinct worlds: the world of physics and the world of psychology. What is infinitesimally small in the physical world may possibly be infinitely great in the psychological world. The residues of nerve-waves, the asymptotic prolongations of curves, may be neglected by the physiologist and the physicist; they are not negligible to consciousness.

Consciousness distinguishes them from the strong vibrations actually going on, which it recognises as "the present"; but the waves that are passed still exist for consciousness, never perhaps to be annihilated.

Assuredly this is but an hypothesis, perhaps an analogy, a comparison, rather than an hypothesis; but it is none the less interesting to note how far the physiological theory of the damping of the nerve-wave is in agreement with the grand psychological fact of memory, which it is scarcely possible to explain in any other way.

IX.

Thus the nerve-wave in its form and period, and in the mode of its damping, is comparable with the various waves of the unbounded universe in which we live, move and have our being. But this resemblance must not lead us away from the recognition of the abyss that separates the nerve-wave from all the other phenomena within our reach. The vibrations of the forces scattered about us are—at least with the greatest probability—blind phenomena, which know not themselves, which are the slaves of irresistible fatality. The nerve-wave, on the contrary, knows and judges itself; it is self-knowing or self-conscious; it can distinguish itself from the world which surrounds it and shakes it.

Since it possesses intelligence—for intelligence and consciousness are synonymous terms—it is susceptible of perfectibility; it is capable of right reasoning and of wrong reasoning; it can attain a moral ideal forbidden to those brute forces which follow their fated course; it can conceive the idea of truth and justice when it is a question of defending the innocent, of establishing brotherhood among men.

Consciousness, intelligence, the making for higher perfection—these are characters that have nought in common with the characters of other waves; they seem to be phenomena of another, a higher order. This vibration, whose physical conditions we have studied, enters into the domain of morals; and this fact establishes its essential difference from all other vibrations.

Assuredly the prodigiously rapid and regular undulations of light, and of electricity, appeal right justly to our admiration; but nothing is so admirable as this disturbance of the nerve-cell, which is self-knowing, self-judging, self-transforming, which strives to amend itself, and which from the stimuli which strike it can deduce some of the laws ruling the vast universe distinct from it. The nerve-wave of man—himself the last result of evolution—is the most perfect term of the things and of the beings which it is given to us to know.

Vast as is the world, mighty as are the fires of the infinite stars, the intelligence of man is of a higher order than these; and I would fain exclaim with the great philosopher, Immanuel Kant: "More than the starry heaven above my head, one thing fills me with admiration: the moral law in the heart of man."

## *ZOOLOGY AT THE BRITISH ASSOCIATION.*

ON the opening day (Thursday) only the President's address was taken, and the Section then adjourned with the object of hearing addresses in other Sections which were of biological interest. The total number of papers brought before the Section this year was not as large as usual, but they extended over a wide range of zoological subject-matter, as the following outline programme shows:—

Friday morning, morphological papers; Friday afternoon, papers on entomology and mimicry; Saturday, marine biology; Monday, morphology, &c.; Tuesday, papers on sea-fishery questions. The usual reports upon investigations in progress were also submitted.

The morphological papers on Friday were as follows :—

(1) J. J. Lister, on *Astrosclera willeyana*, the type of a new family of calcareous sponges. This remarkable new sponge was brought home by Dr. A. Willey from Lifu in the Loyalty Islands. It has a continuous calcareous skeleton formed by the union of numerous polyhedral spicules to form a branched mass, between which run the soft parts with the system of canals. There are very minute ciliated chambers, and the ciliated cells do not appear to have the usual collars.

(2) Prof. Johnson Symington, on the morphology of the cartilages of the monotreme larynx. The thyroid cartilage of the monotremes (*Ornithorhynchus* and *Echidna*) agrees with that of the higher mammals in consisting of a single cartilaginous mass, but differs in the details and relations of its anterior and posterior cornua. Both the ontogeny and the phylogeny of the mammalian epiglottis support the view that it is a single median structure, and not, as Gegenbaur supposed, the result of fusion of two lateral elements.

(3) N. Bishop Harman, the palpebral and oculo-motor apparatus in fishes. Seventy species of fishes were examined. The simplicity or complexity were not found to agree with differentiation in phylogeny, nor with any scheme of classification, nor in relation to habitat. The source of the complex musculature of the eyelids of Selachians was traced to the branchial musculature of the spiracle, and this was further shown by the inverse ratio existing between the condition of spiracle and nictitating membrane. In those fish in which the latter is at its highest development the spiracle is absent, and *vice versâ*. The condition of the orbital sac, of the supporting rod of cartilage, of the eye-muscles, and of other neighbouring structures in the eyes of various groups of fishes was discussed.

(4) Prof. R. J. Anderson, on the pelvic symphysial bone of the Indian elephant ; and a few notes on rhythmic motion.

(5) C. Dawson and S. A. Woodhead, on the crystallisation of beeswax, and its influence on the formation of the cells of bees.

On Saturday, when some of the zoologists from the French Association visited the Section, a few papers on marine biology likely to prove interesting for joint discussion were taken. Mr. W. Garstang brought forward a first report on the periodic investigation of the plankton and physical conditions of the English Channel during 1899. These investigations have been carried out at regular quarterly intervals during the year, from a steam-tug ; and the observations were made at certain fixed localities along lines between Plymouth and Ushant, from Ushant towards the 100 fms. line, and off the entrance to the Channel. Observations of the water temperature (with deep-sea reversing thermometers) at various depths, and of the salinity (with Mill's water-bottle) of the water were taken ; and collections of plankton were made with an effective closing tow-net specially devised by Mr. Garstang to replace the pump and hose method, which had proved unsatisfactory. This new net, and also that of Dr. C. G. J. Peterson for the quantitative estimation of plankton, were on exhibition and with the rest of the apparatus were shown working. Mr. Garstang's investigations in the Channel are not yet completed, and two further series of observations are still to be made. The record so obtained will be of high value in both marine biological and hydrographical inquiry. Prof. Lankester and others took part in the discussion, and one of the visitors, Baron Jules de Guerne, explained the somewhat similar observations he had been making from the Prince of Monaco's yacht *Princesse Alice*, and described the closing nets he employed. The reports upon the Naples and Plymouth biological stations were also submitted.

On Monday the following papers were taken :—

(1) J. Graham Kerr, the development of *Lepidosiren paradoxa ;* and a note on the hypothesis of the origin of the vertebrate paired limbs. Mr. Kerr had been sent by the University of Cambridge with an expedition in search of *Lepidosiren* to the rivers and swamps of Gran Chaco in Paraguay ; and he gave an interesting summary of the life-history of this important type.

(2) Dr. J. F. Gemmill, on negative evidence regarding the influence of nutrition in determining sex. Dr. Gemmill shows that certain fixed species of marine animals are under very different conditions of nutrition from the very earliest period, according as they are high or low on the shore, and yet the proportions of the sexes remain unchanged—indicating that in such forms nutrition has no effect in determining sex.

(3) F. P. Morena and A. Smith Woodhead, exhibition of and remarks on a skull of the extinct Chelonian *Miolania* from Patagonia, along with an exhibition of newly-discovered *Neomylodon* remains from Patagonia—a most interesting and important exhibit of these remarkable remains.

(4) G. E. H. Barrett-Hamilton, the fur seals of the Bering Sea. An account of their habits and condition.

The rest of the afternoon was occupied with reports of Committees, which will be noticed below.

On Tuesday, Sir John Murray read a paper on Dr. Peterson's experiments in the Cattegat, with the marking and measuring of plaice in order to determine distribution and growth, and on plaice culture in the Limfjord. By transplanting young fish from the North Sea into the richer feeding grounds of the shallow fjord, it was found that from April to November they increased to five times their original weight. The cost of transportation was one-sixth of a penny per fish, and the price obtained for a fish so fattened was 4*d*.—a notably successful attempt at economic fish culture.

Mr. W. Garstang gave an account of his experiments at Plymouth on the artificial rearing of young sea-fish. In this Mr. Garstang has, so far, been very successful ; and has succeeded in rearing about 50 per cent. of his larvæ through their critical stages to the complete adult organisation. They are fed on plankton, and are kept in "plunger" jars with not more than five larvæ to a gallon of water.

Dr. James Murie gave an account of the Thames Estuary : its physico-biological aspects as bearing upon its fisheries. These papers gave rise to some discussion on marine fish-culture.

Prof. McIntosh, finally, gave a paper on the occurrence of the grey gurnard (*Trigla gurnardus*, L.), and its spawning in inshore and offshore waters. He shows by a monthly examination of the statistics that this important fish does not begin to move into the inshore waters for spawning purposes until after February, and attains its maximum in May. He does not consider that a maximum as late as August in some years can be taken to indicate a second spawning migration, as supposed by the Scottish Fishery Board. Spawning goes on from April to September.

The Reports of Committees submitted to the Section were as follows :—

(1) The Naples Zoological Station.—The British Association table has been occupied by Dr. H. Lyster Jameson, who gives a summary of his work upon the anatomy of certain Gephyrea and allied vermiform organisms. The usual statistics and other information in regard to the station during the year are also given.

(2) Investigations at the Plymouth Marine Laboratory.—This contains two short papers, one on the embryology of the Polyzoa, by T. H. Taylor, and the other on the rearing of larvæ of Echinidæ, by Prof. MacBride. Mr. Taylor's observations were made on the larvæ of *Bowerbankia*, which he successfully carried through their fixation and metamorphosis on strips of celloidin. MacBride found at Plymouth that the larvæ of Echinids would only live in pure water brought from outside the breakwater. He discusses the difficulties, and the conditions necessary for successful rearing of larvæ.

(3) Zoology and Botany of the West India Islands.—This is the final report, and consists of a list of the publications of the Committee. The material which still remains unworked out has been presented to the British Museum.

(4) Zoology of the Sandwich Islands.—This ninth report shows what has been published by the Committee during the year, and gives the plans for further exploration in the Islands in conjunction with the Honolulu Museum.

(5) Bird Migration in Great Britain and Ireland.—The labour of working out the numerous records obtained from lighthouse-keepers is still being continued by Mr. Eagle Clarke, and a conclusive report is not yet possible.

(6) Zoological and Botanical Publication.—The Secretary of the Committee is in correspondence with editors of academical and periodical publications, and the results will be reported on at a future meeting.

(7) Index animalium.—This great piece of work is still being carried on by Mr. Sherborn, who has indexed about 1500 volumes during the last year. The first section of the Index, dealing with 1758–1800, will soon be ready for publication.

(8) Pedigree Stock Records.—This report is drawn up by Dr. Francis Galton, and deals with the production of photographs, under standard conditions, of prize-winners at shows of pedigree stock, in order to have exact trustworthy records of ancestry.

(9) A circulatory apparatus for experimental observations on marine organisms. The work has been carried out by Mr. F. W. Gamble at the Piel Sea-Fish Hatchery on the Lancashire coast; and the observations chiefly dealt with the changes in colour, and the mechanism of colour physiology in the Crustacean *Hippolyte varians*.

On one of the afternoons Mr. J. W. Woodall took a small party of zoologists to sea in his yacht *Vallota*, to witness the trial of Mr. Garstang's new tow net, which can be opened and closed in any depth of water. In addition to the actual proceedings in Section D, it may be noted that there was a good deal in several of the other Sections that was of zoological interest.

## THE SEVENTH INTERNATIONAL GEOGRAPHICAL CONGRESS.

AT the close of the Sixth International Geographical Congress in London in 1895 it was decided that the next meeting should be held in Berlin in 1899, under the auspices of the Berlin Geographical Society. This meeting, with its attendant festivities, has just been concluded. Although the actual sittings of the Congress extended only from September 28 to October 4, the proceedings began a week earlier and were continued more than a week later, by a series of geographical excursions to different parts of the German Empire. Taken as a whole the Congress must be pronounced not only successful, but brilliantly so; it presents a sort of climax in respect of grandeur to the preceding meetings, and suggests that the time has now come for reconsidering the general plan of such gatherings, and starting afresh on lines of plainer living, if not of higher thinking. Here, however, we have only to sketch the work of the Congress just over, not to suggest the plan of its successor.

The Council of the Berlin Geographical Society had the entire charge of the organisation, and by the usage of previous meetings the President of the Society, Baron Ferdinand von Richthofen, professor of Geography in the University of Berlin, was President of the Congress. The personal efforts of Baron Richthofen were unceasing before and during the meeting, and as no German geographer is better known or more widely respected at home and abroad, the accident of his presidency of the Society was singularly fortunate for the success and *éclat* of the Congress. He was supported as secretary by Hauptmann Georg Kollm, and a number of younger geographers who formed a staff of efficient assistant secretaries, but whose names were not brought before the members. Similarly, the various honorary officials—vice-presidents, members of committees, &c., whose names had appeared in circulars sent out some months before the meeting—remained unknown to most of the members, who had left their early circulars at home. There were general programmes, printed in German, English and French, detailing the work for each day, and a supplementary programme of entertainments in German only, with additions and alterations to the list of papers; but there was no daily journal giving a clear view of the work of each day, with the names of presiding officers and a summary of the work of the day before, as at the London Congress. German also was the one language used in the general business, all announcements were made in German only, almost all the notices exhibited were in German and sometimes even in the German script, which can scarcely be looked on as an international character. In London the three languages were used for every written or printed notice and every important verbal announcement. The abstracts of papers, which were circulated daily, were printed in the language of the author only. The foreigner, unversed in the German language and unused to German customs, was somewhat at a disadvantage throughout, both in scientific meetings and at social functions.

These minor matters apart, the organisation left nothing to desire. The grand building of the Prussian Chamber of Deputies, generously lent to the Congress by the Prussian Government, formed a perfect home for the member. A "depositorium," bearing the number of his ticket, received all communications intended for him, an admirably-conducted cloakroom relieved him of hat and coat, and restored them with a swiftness and certainty that seemed magical to the frequenter of British scientific gatherings; a vast refreshment room could serve breakfast, lunch and supper to the whole Congress simultaneously; picture post-cards (more essential than food to the German visitor) were on sale in every room, even in the Great Hall while papers were being read; desks were provided for issuing tickets, badges and the many offerings of books, maps, &c., presented by institutions and firms; while the luxurious reading- and writing-rooms of the Prussian Deputies were thrown open absolutely without reserve. As an example of international hospitality, the installation of the Congress was memorable and unique. Perhaps the best managed of all the hospitable arrangements was the Ladies' Committee, specially charged with the care of the lady associates of the Congress, which carried out its work with most satisfactory diligence and completeness.

The Congress commenced informally in true German style by the members dropping in as they arrived on the evening of Wednesday, September 27, to the restaurant of the House of Deputies, where they sat at supper or wandered through the various halls, greeting old friends and forming new acquaintances. Next morning at ten o'clock the formal opening took place with much dignity, the gentlemen appearing in evening dress or uniform with a profuse display of orders. Prince Albrecht of Prussia welcomed the Congress in the name of the Emperor; Prince Hohenlohe, the Imperial Chancellor, welcomed it in the name of the Empire; Herr Studt, the new Prussian Minister of Education, in the name of the kingdom of Prussia, the speeches of these great personages being received in solemn silence. The Burgermeister of Berlin then welcomed the members in the name of the city, and applause, which was not stinted to subsequent speakers, then began. The welcome was responded to by a few of the most distinguished foreigners. Baron Richthofen read his presidential address, on the progress of geography in the nineteenth century; Sir Clements Markham, as president of the sixth Congress, gave a short address, resigning his office and presenting the report of the London Congress. Vice-presidents and chairmen of the different sections were nominated, and the formalities were over.

It is unnecessary to detail the social accompaniments of the Congress. The Imperial Chancellor gave a small dinner and a large reception to the foreigners and the more prominent German members. The city of Berlin gave an admirably conducted dinner to the whole Congress in the Zoological Gardens. The Berlin Geographical Society also entertained all the members to a reception and supper, and there was a special performance in the Opera House.

It is impossible to pass without remark the magnificent hospitality of Hamburg, where over 500 members of the Congress were received by the local Geographical Society, and carried through two days of uninterrupted festivity. The Senate opened the State rooms of the new Town Hall, probably the finest municipal building in the world, for the first time in honour of the visitors, and an even more impressive view of the vast wealth and activity of the greatest continental seaport was afforded by a cruise through the harbour and a visit to the floating docks and ship-building works. The Hamburg-America Line entertained a thousand guests to lunch in the "'tween-decks" of the *Pretoria*, said to be the largest cargo steamer afloat, and this on the day before she sailed for New York with a full cargo and complement of passengers. No less hearty and no less interesting were the receptions accorded to the members of the various excursions to the Baltic shores, the Rhine and Central Germany by the local authorities and geographical societies.

The serious business of the Congress was divided into a general meeting in the forenoon from ten to one, and three simultaneous meetings in the afternoon, commencing at two o'clock, and sitting until five or even six. A time-limit for speakers was formally announced, but rarely, if ever, enforced; and the system of allowing one speaker to address the meeting as often as he liked on the same subject led to the degeneration of some of the debates into long-winded dialogues.

The programme with its additions bore the titles of no less than 150 papers, many of which were intended to be introductory to discussions. This number might have been reduced with great advantage. A few were the work of "cranks," a good many were old or of no international interest; but the great majority were new and valuable and deserving of far more complete discussion than their number made it possible for them to receive.

The departments of Geography which received most attention at the Congress were, perhaps, Antarctic Exploration, Oceano-

graphy and Plant-Geography. Dr. Erich von Drygalski gave a detailed account of the plans for the German Antarctic expedition, which is to sail in 1901, and submitted the specifications for the ship and her equipments. All the preparations for the expedition are in a forward state. Dr. Drygalski himself is the scientific leader, the captain of the ship being simply a sailing-master responsible for the navigation. Dr. Vanhöffen, who accompanied Dr. Drygalski in his Greenland expedition, goes as botanist, and several other members of the scientific staff, which will number at least six, have been chosen. Much stress is laid on the importance of co-operation with the British expedition. Dr. Drygalski hopes to land somewhere to the south of Kerguelen, that island being occupied by a land-party as a scientific base, and to advance towards the South Pole by the aid of dogs. Sir Clements Markham gave a full exposition of the plans of the British expedition. He said that the vessel for the expedition will be built of oak with an ice-casing of harder wood. She will be 172 feet long by 33 broad, with a displacement of about 1525 tons. Arrangements will be made for a magnetic observatory before the mainmast, which shall have no iron within 30 feet of it. There will be accommodation for six executive officers, including two engineers, three civilians for biology and geology, including the surgeon, and thirty-nine men. Melbourne will be the base for magnetic observations, and a party will be landed in MacMurdo Bay, near Mount Erebus, to push inland with sledges, but without dogs, the use of which involves unjustifiable cruelty. In the discussion on the Antarctic papers, Dr. Nansen strongly defended the use of dogs, the alternative being in his opinion far greater cruelty to men. Sir John Murray urged the importance of circumpolar oceanographical investigations as a preliminary to the penetration of the Antarctic ice-pack. M. Arçtowski read a paper on the oceanographical and meteorological results of the *Belgica's* voyage, and Prof. Nielsen of Christiania gave some account of Sir George Newnes' expedition under Mr. Borchgrevink.

In north polar exploration the most important papers were the first public statements regarding the scientific results of the *Fram* expedition. Dr. Nansen in a lecture of an hour and a half's duration described the North Polar Basin as revealed by his soundings, and discussed the distribution of temperature and the circulation of water in it in great detail, while Prof. Mohn in another paper gave a *résumé* of the meteorological results. It is impossible in a few lines to summarise either of these massive contributions to knowledge.

Oceanographical papers were numerous, that of Prof. Chun, the leader of the *Valdivia* expedition, exciting the greatest amount of interest. Sir John Murray discussed the distribution of deep-sea deposits over the ocean floor, and the Prince of Monaco described some of the results of his recent cruise to Spitsbergen. Several useful and really international discussions took place, culminating in the appointment of committees to draw up a systematic terminology and nomenclature for the forms of sub-oceanic relief, introduced by Profs. Wagner, Krümmel, Voiekoff and Dr. H. R. Mill, and to determine a common method of expressing the density of sea-water, introduced by Baron Wrangell and Prof. Pettersson.

There were several valuable papers on subjects involving climatology, limnology, the study of glaciers and seismology, and one on kumatology by Mr. Vaughan Cornish; indeed it would be difficult to mention any department of physical geography to which some contribution was not made.

The geography of plants was discussed with particular thoroughness, both with regard to the distribution of special types of vegetation and the more general relations of nomenclature and cartographic representation. Profs. Drude, Engler, Warburg, Krasnoff and Nehring dealt with these subjects.

The geological aspects of geography produced several papers of unusual value, including one by Prof. de Lapparent on the question of peneplains, one by Prof. Penck on the deepening of alpine valleys, and one by Mrs. Gordon (Dr. Maria Ogilvie) on the basins of southern Europe. Mr. W. Obrucheff, of St. Petersburg, gave an important account of the orography and tectonic structure of the trans-Baikal region of Siberia as revealed by the most recent observations—between 1895 and 1898; and Prof Philippson discussed the Ægean region in a similar way.

The human and historical aspects of geography were not left in the background. Prof. Ratzel discoursed on the origin and dispersal of the Indo-Germanic peoples, and Prof. Sieglin on the discovery of England in ancient times. Papers were read on the need of fresh organisation in obtaining statistics of population in unorganised countries by Dr. Scott Keltie, and on means of representing such statistics on maps by Prof. Hettner. Prof. Neovius, of Helsingfors, exhibited a remarkable atlas of Finland recently completed by the Finnish Geographical Society, in which all the conditions of the land, natural and economic, are mapped with a completeness that has never been attempted for any other country. It even includes a map showing in horse-power the available energy of the rivers.

As was to be expected there were many papers on geography in its educational aspects. Amongst these one by Prof. Ratzel on geographical position as the central fact in geographical education was perhaps the most important.

The last meeting of the Congress was to have been addressed by Prof. Hergesell on the results of international balloon investigations, but the author somewhat rashly made an ascent the previous morning in a balloon, which carried him so far towards the Russian frontier that the Congress had been formally closed before the slow means of terrestrial locomotion brought him back to Berlin.

No better bird's-eye view of the work of the Congress can be given than by presenting in a condensed form the series of resolutions passed at the final meeting, which are intended to minister to more complete international co-operation in the work of scientific investigations.

### RESOLUTIONS OF THE SEVENTH INTERNATIONAL GEOGRAPHICAL CONGRESS.

(The order is that in which the resolutions were presented.)

(1) The Congress appoints a Committee of Bio-geographers resident in or near Berlin to draw up a uniform scheme of nomenclature for plant-formations, and after consultation with non-resident specialists, to revise the same and present it to the Eighth Congress.

(2) The Congress believes that the plans for international co-operation in Antarctic exploration form an excellent basis for joint research in physical geography, geology, geodesy and biology. With regard to meteorological and magnetic work, however, they appoint an international committee to determine the general scheme and methods to be employed on the expeditions, and to endeavour to organise a system of simultaneous observations in the regions surrounding, but exterior to, the Antarctic.

(3) The Congress expresses the earnest desire that all maps, including those published in countries using English and Russian measures, should, in addition to the graphic scale, bear the proportion of lengths on the map to those in nature in the usual form $1:x$.

(4) The Congress views it as desirable that the publication of all new geographical material accompanying accounts of travel, should be supported by details regarding the methods of surveying, the instruments employed, and their verification, the calculation of astronomical positions with their probable error, and the method of utilising these data in preparing the map. Also that all maps published by scientific men, institutions or governments should be accompanied by notes of the principal fixed points.

(5) The Congress expresses the hope that a uniform system of measures will be used in all geographical researches and discussions, and recommends that the metric system of weights and measures be so employed.

(6) The Congress expresses the hope that in scientific publications the centigrade thermometer scale should, as far as possible, be employed; or, at least, the values in centigrade degrees added to those expressed on the scales of Fahrenheit or Réaumur.

(7) With regard to the proposal to introduce a decimal division of time and angles, the Congress desires to preserve the present division of time and of the circumference into 360°, but allows that the adoption of a different subdivision of the angle might be studied, and considers that in certain cases the decimal subdivision of the degree of arc presents no objection.

(8) The Congress is of opinion that the *Bibliotheca Geographica*, published by the Berlin Geographical Society, may be accepted as an efficient international bibliography of geography.

(9) The Congress considers the construction of statistical population maps to be very desirable, and appoints an international committee to draw up a scheme, at the same time expressing the hope that national committees will be formed in various countries to promote the preparation of such maps.

(10) The Congress considers the collection of data as to the

distribution of floating ice to be very important, and appeals to the hydrographic and meteorological institutes of the countries whose ships frequent high latitudes to induce the masters of vessels to keep a regular record of the occurrence of drifting ice. The Congress believes that the Danish Meteorological Institute in Copenhagen is the best adapted as an international centre for collecting the records.

(11) The Congress nominates an international committee to consider the nomenclature of the floor of the ocean, and to produce and publish at latest in time for the next Congress a chart of the ocean with revised nomenclature.

(12) The Congress hopes that the names of oceanic islands, especially in the Pacific, will be revised with a view to ascertaining and preserving the native names. Where no native names exist or can be ascertained, the names given by the discoverers should be used. The arbitrary changing of established names ought to be opposed by every means.

(13) The Congress recognises the desirability of obtaining data for a more exact estimate than now exists of countries in which there is no means of taking a census, and desires to bring the matter to the notice of such Governments as have foreign possessions.

(14) The Congress expresses sympathy with the proposal to equip an expedition in New South Wales, with the sole object of endeavouring to discover remains or traces of the route of the Leichhardt expedition, which perished in the interior of Australia fifty-two years ago.

(15) The Congress is favourable to the foundation of an international seismological society, and appoints an international committee for the study of earthquakes.

(16) The Congress believes the production of a map of the world on the scale of 1 : 1,000,000, the sheets bounded by meridians and parallels, to be both useful and desirable. The Permanent Bureau of the Congress is instructed to deal with the question, and in the first instance to secure the preparation of a projection for the map with degree-lines on the determined scale.

(17) The Congress considers the establishment of an International Cartographical Association of service, and appoints a committee to take preliminary steps.

## *THE SCIENTIFIC CONFERENCE AT WIESBADEN.*

WE refer in a leading article to one of the most important developments of scientific organisation which our time has seen. The proceedings at a recent conference at Wiesbaden, dealing with this matter, are thus stated in Monday's *Times* :—

"For several years past there has existed an Association or Cartell of the Academies of Sciences of Munich and Vienna and of the Royal Societies of Sciences of Göttingen and Leipzig, which has met yearly to discuss matters of common interest, and the combined action of these bodies has in several ways been fruitful of results. Representatives of the Royal Society of London attended the meeting held last year at Göttingen, as well as that which took place the previous year at Leipzig, chiefly with the object of discussing the project of an international catalogue of scientific literature which the society has been engaged in promoting.

"When the invitation was conveyed to the Royal Society of London to send representatives to the Göttingen meeting it was intimated that the Cartell would be glad to learn the views of the society as to the possibility of its joining the association. The delegates appointed from London were instructed to state that the Royal Society would be disposed to join provided that the organisation were so extended as to assume a truly international character. This suggestion was not only accepted in principle at Göttingen, but it was agreed that the Royal Society of London should be requested to take the steps, if thought desirable, to ascertain how far the establishment of such an international association would commend itself to the leading scientific bodies of other countries.

"The Royal Society of Sciences of Berlin, although not included in the Cartell, has for several years past been represented at its meetings. When the Royal Society of London had ascertained that the project was likely to find favour it was agreed that the Royal Society and the Berlin Academy should together issue an invitation to the Academy of Science, Paris, the Imperial Academy of Sciences, St. Petersburg, the Reale Accademia dei Lincei, Rome, the National Academy, Washington, U.S.A., as well as to the bodies included in the Cartell, requesting them to send delegates to a conference to be held in Wiesbaden on the 10th and 11th of this month.

"At the conference, excepting the Reale Accademia dei Lincei, which was unable to send delegates, although in full sympathy with the movement, all the bodies invited were represented—the Berlin Academy by Messrs. Auwers, Virchow and Diels; the Göttingen Society by Messrs. Ehlers and Leo; the Leipzig Society by Messrs. Windisch and Wislicenus; the Royal Society by Messrs. Rücker, Armstrong and Schuster; the Munich Academy by Messrs. von Zittel Dyck and von Sicherer; the Paris Academy by Messrs. Darboux and Moissan; the St. Petersburg Academy by Messrs. Famintzine and Salemann; the Washington Academy by Messrs. Newcomb, Remsen and Bowditch; and the Vienna Academy by Messrs. Mussafia, von Lang, Lieben and Gomperz.

"Prof. Auwers, one of the secretaries of the Berlin Academy, occupied the chair, and the success of the meeting was largely due to the extreme ability and tact, combined with judicious firmness, with which he conducted the proceedings. Besides showing himself a master of the three languages—German, French and English—used in the debates, he was thoroughly informed on every point which came up for discussion. Fortunately, all the delegates appeared to be actuated by the desire to co-operate, and there was little difficulty in framing statutes which all were prepared to accept.

"The immediate outcome of the conference has been that it is resolved to found an international union of the principal scientific and literary bodies of the world, the object of which will be to initiate or promote scientific enterprises of general interest recommended by one or more of the associated bodies, and to facilitate scientific intercourse between different countries. It is to be known as the International Association of Academies. A number of important bodies besides those represented at Wiesbaden are to be invited to join. General meetings of delegates from the various constituent academies are to take place, as a rule, at intervals of three years, but the interval may be varied and special meetings held if necessary. The Royal Society had proposed, prior to the conference, that the first general meeting should be held in Paris next year. At the general meetings two sections will be constituted, one dealing with mathematics and the natural sciences, the other with arts and philosophy.

"A council is to be appointed which will carry on the business in the intervals between meetings. The formation of committees of experts to initiate and promote scientific investigations of international importance is also contemplated.

"It remains to be mentioned that the Berlin Academy had also arranged for the entertainment of the delegates at the close of the debates. On the Monday evening they were invited to attend a performance of Lortzing's opera *Undine*, and on the Tuesday they were entertained at dinner in the Kurhaus. On the latter occasion Prof. Virchow occupied the chair, and opened the proceedings by toasting the delegates generally; he was followed by Prof. Darboux, of Paris, who proposed the health of the Berlin Academy. In the course of the evening, in characteristic German style, every other possible toast was proposed by one or other of the delegates.

"It is to be hoped that when the statutes framed at the conference are communicated to the various bodies interested they will meet with approval, and that the establishment of the organisation will soon be an accomplished fact. In times when political feeling is so strongly developed the provision of a common platform on which all nations can meet amicably and co-operate in furthering scientific enterprises must prove of the very greatest value; and if the spirit of amity which prevailed at the conference be extended to future meetings the success of the association is assured."

## *UNIVERSITY AND EDUCATIONAL INTELLIGENCE.*

CAMBRIDGE.—Sir Michael Foster has been reappointed a manager of the Balfour Fund for zoological research.

Mr. Yule Oldham, reader in geography, is giving three courses of lectures this term: (1) on the Geography of Europe, for history students; (2) on Physical Geography; and (3) on the History of Geographical Discovery.

The degree of M.A. honoris causa is to be conferred on Dr. Somerville, the recently-elected Professor of Agriculture.

Mr. W. N. Shaw, F.R.S., is reappointed Assistant-Director of the Cavendish Laboratory.

Prof. D. J. Cunningham, F.R.S., of Dublin, is appointed an Elector to the chair of Anatomy, and Prof. W. F. R. Weldon, F.R.S., of Oxford, an Elector to the chair of Zoology, in succession to the late Sir W. H. Flower.

Dr. D. MacAlister, of St. John's College, has been re-elected a representative of the University on the General Medical Council for five years.

Fifteen candidates have passed the recent examination in sanitary science, and have thus qualified for the Diploma in Public Health.

THE destruction of the Technical Institute at West Ham by a fire which occurred on Monday night, and was first discovered in the chemical laboratory, is a disaster to technical education in London. The Institute commenced a short time ago an admirable programme of work in science and technology, and as it was the only municipal technical institute in the metropolitan area, its career has been closely followed. The damage done is estimated at over 80,000*l.*, only part of which is covered by insurance.

THE systematic study of geography is so much neglected in this country that it is to be hoped the School of Geography recently established at Oxford will be successful. During the present term Mr. H. J. Mackinder, the University Reader in Geography, will lecture on the historical geography of the British Isles. The lecturer in physical geography (Mr. Dickson) will lecture on the climate of the British Isles. The assistant to the Reader (Dr. Herbertson) will lecture on the geomorphology of Europe; and the lecturer in ancient geography (Mr. Grundy) will lecture on the general historical topography of Greece. Dr. Herbertson will give instruction in cartography and practical geography, with field work; and during the term special attention will be given to the study of map projections, and of physical maps of all kinds.

ANOTHER addition to the laboratory equipment of our public schools has recently been made at Felsted, where new buildings for the teaching of science were opened last week. The laboratory consists of a lecture room with raised seating and a gallery, the lecture table being provided with down draught and electricity for experimental purposes, and behind it a faced wall surface for the lantern. The chemical laboratory is a room about thirty feet square to accommodate twenty-six boys, and has an adjoining balance room. In addition there is a general physical laboratory for a like number of boys, a special laboratory for senior physics, an optical room, store room and workshop. The building is in a large measure a gift of one of the governors of the school, and has been erected under the direction of Mr. A. E. Munby. It was opened by Dr. Garnett, of the London County Council, who gave an address on science as a means of general education. Sir John Gorst recently visited the building and expressed his warm approbation of the arrangements.

PRACTICAL science in rural districts, as a means of benefiting British agriculture, has, we are glad to observe, received much support lately. The meeting of the Agricultural Education Committee, held at the Society of Arts on Friday last, showed the existence of a strong feeling that active efforts should be made to secure systematic and efficient instruction, both theoretical and practical, in agricultural subjects suitable to every class engaged in agriculture; and to diffuse among the agricultural classes a more thorough appreciation of the advantages of instruction bearing directly or indirectly on their industry. The chairman, Sir William Hart Dyke, explained that the province of the committee, as a united body, was to bring pressure upon Parliament and upon public opinion to establish in rural schools rational courses of instruction bearing upon agricultural pursuits. The following resolutions were subsequently adopted:—(1) That, in the proposed organisation of the new Board of Education, due regard should be had to the interests of agricultural instruction. (2) That proper provision should at once be made at certain of the Teachers' Training Colleges for giving to those who desire it both theoretical and practical instruction in subjects bearing on agriculture and horticulture. (3) That, after a certain date to be named in next year's code, instruction in the elementary branches of natural science bearing on agriculture should be made compulsory in rural elementary schools, and that such instruction should be accompanied and illustrated by experiments, and (where possible) by practical work in plots of ground attached to the schools. (4) That county authorities be encouraged to provide experimental and school farms, and to contribute, by scholarships and otherwise, to some agricultural college or department of the first rank. The realisation of the conditions expressed in these resolutions should be desired by every one interested in national progress.

## SCIENTIFIC SERIAL.

*Wiedemann's Annalen der Physik und Chemie*, No. 9.—Dispersion of gypsum, by W. König. The author studies the dispersion of gypsum in the visible spectrum by observing the influence of wave-length upon the width of interference fringes produced by means of wedges made of that material.—Electric charge of freshly-prepared electrolytic gases, by W. Kösters. Hydrogen and oxygen are positively electrified by passing through sulphuric acid, and this may help to explain the positive charge of the same gases when produced by electrolysis. In other cases, however, the gases passed through a liquid do not assume the same electrification as when generated by electrolysis.—Further experiments with Becquerel rays, by J. Elster and H. Geitel. Thinking that the radiation of uranium and thorium compounds might be influenced by the impact of kathode rays, the authors exposed a piece of Joachimsthal pitchblende to kathode rays, but they could not trace any influence of the rays. The authors believe the Becquerel rays to be Röntgen rays of small intensity. They support this view by showing that they are not deflected by a magnet (see p. 623).—Radio-active baryta and polonium, by F. Giesel. The author describes the preparation of the radio-active barium salts. He has not yet succeeded in isolating the active principle, whether radium or polonium.—Canal and kathode rays, by P. Ewers. The writer does not share the prevalent opinion that canal rays consist of projected anode particles, since the quantity of electricity conveyed by them varies with the material of the kathode, but not with that of the anodes. He concludes that the canal rays consist of positive ions of the material of the kathode, but the matter thus conveyed to the wall is so small that it would require 288 hours of continuous working to deposit one milligramme of aluminium.—Law of development of Hittorf's dark space, by H. Ebert. Hittorf's dark space is the narrow space which immediately adjoins the luminous kathode layer. Its width increases as exhaustion proceeds, and does so in accordance with a geometrical series when the pressure diminishes in another geometrical series. The indices of the series are, however, generally different.—Magnetic susceptibilities of inorganic compounds, by S. Meyer. Judging from their compounds, the rare elements lanthanum, cerium, praseodymium, samarium, gadolinium, and especially erbium, must be strongly magnetic. Erbium oxide is four times as strongly magnetic as $Fe_2O_3$, and if the conclusion as to their bases is correct, erbium must be, weight for weight, six times as strongly magnetic as iron. This would have an important practical signification if erbium were to be found in large quantities.

## SOCIETIES AND ACADEMIES.

### PARIS.

**Academy of Sciences**, October 16.—M. van Tieghem in the chair.—On the positions of equilibrium of a ship carrying liquid cargo, by M. Appell. The author develops a problem of M. Guyou, giving a means of finding the positions of equilibrium and discussing their stability.—Method of setting a collimator, by M. G. Lippmann. The slit is observed with an auxiliary telescope, and between this and the collimator a biplate is inserted. In general two images of the slit are observed, but on adjusting the collimating lens, at one point the two images coincide; the rays issuing from the collimator are now parallel. The accuracy of the adjustment is limited only by the resolving power of the telescope.—Production of ozone by the decomposition of water with fluorine, by M. Henri Moissan. A rapid current of fluorine, prepared in a copper apparatus, is passed

into water kept at 0°. The ozonised oxygen thus set free was carefully analysed by treatment with potassium iodide and measuring the iodine set free. The percentage of ozone was on one occasion as high as 14·4 per cent., and this preparation, although somewhat delicate, is not costly. The ozone produced in this way is absolutely free from all trace of oxides of nitrogen, and may possibly have industrial applications.—The preventive qualities of the blood serum of an immunised heifer against contagious peripneumonia in cattle, by MM. S. Arloing and Duprez. The direct inoculation for peripneumonia suggested by M. Willems has two disadvantages: some time is required to develop the protective effects, and occasionally fatal tumours occur. A heifer was directly inoculated with gradually increasing amounts of venom until it became capable of resisting a dose five hundred times greater than would be sufficient to kill an unprotected animal. The serum of this heifer was used in the experiments, which were not altogether conclusive, since one of the injected animals caught the disease, whilst another, although unprotected, escaped.—Report on an earthquake at Smyrna on September 20, by the French Consul General at Smyrna.—Observations of the Giacobini Comet (September 29, 1899), made at the Observatory of Algiers, with the equatorial of 31·6 cm. aperture, by MM. Rambaud and Sy.—On a problem relating to the congruences of right lines, by M. E. Goursat.—On the classification of projective groups in space of $n$ dimensions, by M. F. Marotte.—Theory of the number of roots of an algebraic equation comprised in the interior of a given circumference, by M. Michael Petrovitch.—On the reactions of induction of alternators, by M. A. Blondel.—Experiments in telegraphy without wires, carried out between Chamonix and the summit of Mont Blanc, by MM. Jean and Louis Lecarme. The communications were interfered with by the ice, or by the absence of water in the soil; neither were the effects of atmospheric electricity sufficient to stop the messages, but during the time the electric light at Chamonix was in action working was impossible.—Radiographic bulb with a cold antikathode, by MM. Abel Bugnet and Victor Chabaud. The platinum tube forming the antikathode is fused directly to the glass, and is kept cool by cold water. Very powerful discharges from large induction coils can be used with this tube without any heating of the platinum resulting.—On a new radio-active material, by M. A. Debierne. A new radio-active substance has been isolated from pitchblende. It is distinguished from polonium and radium by its chemical properties, which resemble titanium very closely, and also by the fact that it is not spontaneously luminous. The rays emitted by this substance, for which no name is as yet suggested, are about 100,000 times stronger than those given off by uranium. They render gases capable of discharging electrified bodies, excite the phosphorescence of barium platinocyanide, and affect photographic plates.—On the atomic weight of boron, by M. Henri Gautier. The author, after reviewing the earlier work of Berzelius, Abrahall, and Ramsay and Aston, attempts to prepare compounds of boron of the constancy of composition of which there can be no doubt, and selects the sulphide $B_2S_3$ and carbide $B_6C$ for a preliminary study.—On anhydrous magnesium carbonate, by M. R. Engel.—On the heat of oxidisation of tungsten, by MM. Delépine and Hallopeau. The usual methods of combustion at ordinary pressure, combination with a halogen, attack by water or acid having failed for tungsten, the method of burning in the calorimetric bomb was tried, and after some preliminary experiments was found to give good results, the mean value per gram of tungsten being 1062 calories. In forming the oxides $TuO_2$ and $TuO_3$, each atom of oxygen has nearly the same calorific value.—Action of potassium-ammonium upon arsenic, by M. C. Hugot. With the alkaline ammonium in excess, $AsK_3$ is formed; with arsenic in excess, $As_4K_2$.—Action of bromine in presence of aluminium chloride upon some chloro-benzenes, by M.M. A. Mouneyrat and Ch. Pouret. Bromine acts readily upon chlorobenzene in presence of aluminium chloride, and gives an excellent yield of $p$-bromo-chlorbenzene. The following compounds have been obtained by this method: $C_6Br_5Cl$, [1, 4] $C_6Br_4Cl_2$, [1, 2, 4] $C_6Br_3Cl_3$, [1, 2, 4, 5] $C_6Br_2Cl_4$, and $C_6Br_4Cl(CH_3)$.—On the constitution of the colouring matter of leaves; chloroglobin, by M. Tsvett.—Demonstration of the disaggregation of leucocytes and the solution of their contents in the blood plasma during hypoleucocytosis. Influence of intravascular leucolysis on the coagulation of the blood, by M. Henri Stassano.—Germination of the seed of the carob; production of mannose by a soluble ferment, by MM. Ed. Bourquelot and H. Hérissey. During the germination of the carob seed there is soluble ferment produced, which acts upon the stored albumen similarly to diastase upon amylaceous albumens, mannose and galactose being the products.—On *Aplosporidium*, a new order of the class of Sporozoa, by MM. Maurice Caullery and Félix Mesnil.—Calcified suberous layers from the coal measures of Hardinghen, by M. C. Eg. Bertrand.—On the composition and food value of the principal fruits, by M. Balland.—Submarine lithology of the coasts of France, by M. J. Thoulet.

## DIARY OF SOCIETIES.

*THURSDAY*, October 26.

Camera Club, at 8.15.—Illusions and Anomalies of Vision: Shelford Bidwell, F R.S.

*FRIDAY*, October 27

Physical Society, at 5.—The Magnetic Properties of the Alloys of Iron and Aluminium: Dr. S. W Richardson.—Exhibition of a Model illustrating a Number of the Actions in the Flow of an Electric Current: G. L. Addenbrooke —Repetition of some Experiments with the Wehnelt Interrupter devised by Prof Lecher: W. Watson

Institution of Mechanical Engineers, at 7.30.—The Incrustation of Pipes at Torquay Water Works: William Ingham.—A Continuous Mean-Pressure Indicator for Steam Engines: Prof. William Ripper.

*WEDNESDAY*, November 1.

Entomological Society, at 8—Exhibition of Lepidoptera from Bulgaria: H. J. Elwes, F.R.S, and Mrs. Nicholl.

Society of Public Analysts, at 8.—The Meaning of the Acetyl Value in Fat Analysis (with Lantern Illustrations): Dr. J. Lewkowitsch.

*THURSDAY*, November 2.

Linnean Society, at 8.—On the Proliferous State of the Awn of Nepal Barley: Rev. Prof. Henslow.—On the Hyobranchial Skeleton and Larynx of the New Aglossal Toad, *Hymenochirus Boettgeri*: Dr. W. G. Ridewood.—On the Eye-spot and Cilium in *Euglena viridis*: Harold Wager.

Chemical Society, at 8.—The Theory of Saponification: J. Lewkowitsch.—The Action of Dilute Nitric Acid on Oleic and Elaidic Acids: F. G. Edmed.—Tetrazoline: Siegfried Ruhemann and H. E. Stapleton.—On Ethylic Dibromobutanetetracarboxylate and the Synthesis of Tetrahydrofurfuran-αα′-dicarboxylic Acid: Dr. Bevan Lean.—(1) Camphoroxime. Part III. Behaviour of Camphoroxime towards Potassium Hypobromite; (2) Optical Influence of an Unsaturated Linkage on certain Derivatives of Bornylamine: Dr. M. O. Forster.

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# NATURE

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*"To the solid ground*
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No. 1540, Vol. 60] THURSDAY, MAY 4, 1899. [Price Sixpence.

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# NATURE

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No. 1541, Vol. 60] THURSDAY, MAY 11, 1899. [Price Sixpence.

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No. 1542, Vol. 60] THURSDAY, MAY 18, 1899. [Price Sixpence.

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## ROYAL INSTITUTION OF GREAT BRITAIN,

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Prof. L. C. MIALL, F.R.S., will on Thursday next, May 25th, at Three o'clock, begin a Course of Two Lectures on "Water Weeds."

Subscription for this Course, Half-a-Guinea.

## INDIAN GEOLOGICAL SURVEY.

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The Salary of the Post is 900 Rupees a month; and the Appointment will be for a term of five years.

Further particulars will be furnished on written application to the REVENUE SECRETARY, India Office, Whitehall.

A. GODLEY, Under-Secretary of State.

India Office, 3rd May, 1899.

## SWANSEA MUNICIPAL TECHNICAL SCHOOL.

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L. COLLWYN LEWIS, Secretary.

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Applications, with one set of copies of testimonials, should be addressed to the HEAD MASTER, and should reach him not later than Wednesday, May 24th.

L. COLLWYN LEWIS, Secretary.

## UNIVERSITY COLLEGE, LONDON.

JODRELL PROFESSORSHIP OF ZOOLOGY.

This Chair will be vacant by the resignation of Prof. Weldon at the close of the present Session.

Applications, accompanied by such testimonials as Candidates may wish to submit, should reach the Secretary by Monday, June 5, 1899.

Further information will be sent on application to the SECRETARY.

The new Professor will enter on his duties in the October following.

J. M. HORSBURGH, M.A., Secretary.

## UNIVERSITY OF ST. ANDREWS.

CHAIR OF PATHOLOGY.

In accordance with the terms of Ordinance No. 47 (St. Andrews, No. 6) of the Commissioners, under the Universities (Scotland) Act 1889, the University Court will appoint a PROFESSOR OF PATHOLOGY, who shall conduct Classes at Dundee qualifying for graduation in Medicine; the appointment to date from October 1, 1899. Applications, accompanied by twenty copies of testimonials, to be lodged by 21st JUNE next, with Mr. J. E. WILLIAMS, Secretary of the University, from whom further information may be obtained.

St. Andrews, May 1899.

## UNIVERSITY OF ST. ANDREWS.

The UNIVERSITY COURT OF ST. ANDREWS will, at a meeting to be held in the month of July, appoint an ADDITIONAL EXAMINER for Graduation in the subject of NATURAL HISTORY.

Applications, with testimonials, to be lodged by 21st June next with the undersigned, from whom further information may be obtained.

JNO. E. WILLIAMS, Secretary.

St. Andrews, May, 1899.

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Applications, accompanied by copies only of testimonials, must be sent in before June 30, 1899, marked outside "English Masterships," and addressed to the SECRETARY-GENERAL, Ministry of Public Instruction, Cairo, Egypt, to whom Candidates may apply for further information.

## MUNICIPAL TECHNICAL SCHOOLS, PLYMOUTH.

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No. 1543, Vol. 60] THURSDAY, MAY 25, 1899. [Price Sixpence.

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No. 1544, Vol. 60] THURSDAY, JUNE 1, 1899. [Price Sixpence.

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No. 1545, Vol. 60] THURSDAY, JUNE 8, 1899. PRICE ONE SHILLING.

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No. 1546, Vol. 60] THURSDAY, JUNE 15, 1899. [Price Sixpence.

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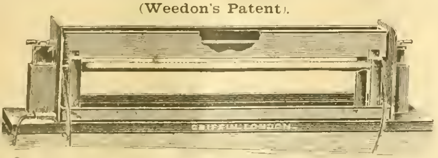




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